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Driving sustainable change in antimicrobial prescribing practice – How can social and behavioural sciences help?

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Short running title: Applying behavioural and social science to antimicrobial stewardship

Statement of contributions: P Davey conceptualised the manuscript. F Lorencatto led the drafting of the manuscript. E Charani, N Sevdalis, & C Tarrant are presented in alphabetical order and contributed equally to the drafting of the manuscript. All authors approved the final version.

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Transparency declarations:

Sevdalis is the director of London Safety and Training Solutions Ltd, which undertakes patient safety and quality improvement advisory and training services for healthcare organisations internationally.

SYNOPSIS

Addressing the growing threat of antimicrobial resistance is in part reliant on the complex challenge of changing human behaviour- in terms of reducing inappropriate antibiotic use and preventing infection. Whilst there is no ‘one size fits all’ recommended behavioural solution for improving antimicrobial stewardship, the behavioural and social sciences offer a range of theories, frameworks, methods and evidence-based principles that can help inform the design of behaviour change interventions that are context-specific and thus more likely to be effective. However the state-of-the art in antimicrobial stewardship research and practice suggests that behavioural and social influences are often not given due consideration in the design and evaluation of interventions to improve antimicrobial prescribing. In this paper, we discuss four potential areas where the behavioural and social sciences can help drive more effective and sustained behaviour change in antimicrobial stewardship: 1) defining the problem in behavioural terms and understanding current behaviour in context; 2) adopting a theory-driven, systematic approach to intervention design; 3) investigating implementation and sustainability of interventions in practice; and 4) maximising learning through evidence synthesis and detailed intervention reporting.

Key words: antimicrobial stewardship, prescribing practice, behaviour change, behavioural science, social science, behaviour change intervention

BACKGROUND

In healthcare, gaps remain between clinical practice and recommendations based on evidence, policy, and guidelines { ADDIN EN.CITE

<EndNote><Cite><Author>Grol</Author><Year>2003</Year><RecNum>3</RecNum><DisplayText>[1]</DisplayText><record><rec-number>3</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">3</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Grol, Richard</author><author>Grimshaw, Jeremy</author></authors></contributors><titles><title>From best evidence to best practice: effective implementation of change in patients' care</title><secondary-title>The lancet</secondary-title></titles><pages>1225-1230</pages><volume>362</volume><number>9391</number><dates><year>2003</year></dates><isbn>0140-6736</isbn><urls></urls></record></Cite></EndNote>}. Antimicrobial prescribing is no

exception to this, with many studies documenting overuse and/or misuse of these vital agents in both secondary and primary care { ADDIN EN.CITE

<EndNote><Cite><Author>Hulscher</Author><Year>2010</Year><RecNum>14</RecNum><DisplayText>[2, 3]</DisplayText><record><rec-number>14</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">14</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Hulscher, Marlies E.J.L.</author><author>Grol, Richard P.T.M.</author><author>van der Meer, Jos W.M.</author></authors></contributors><titles><title>Antibiotic prescribing in hospitals: a social and behavioural scientific approach</title><secondary-title>The Lancet infectious diseases</secondary-title></titles><pages>167-175</pages><volume>10</volume><number>3</number><dates><year>2010</year></dates><isbn>1473-

3099</isbn><urls></urls></record></Cite><Cite><Author>Cars</Author><Year>2001</Year><RecNum>37</RecNum><record><rec-number>37</rec-number><foreign-keys><key app="EN" db-

id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508152557">37</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Cars, Otto</author><author>Mölstad, Sigvard</author><author>Melander, Arne</author></authors></contributors><titles><title>Variation in antibiotic use in the European Union</title><secondary-title>The Lancet</secondary-title></titles><periodical><full-title>The lancet</full-title></periodical><pages>1851-1853</pages><volume>357</volume><number>9271</number><dates><year>2001</year></dates><isbn>0140-6736</isbn><urls></urls></record></Cite></EndNote>}. Interventions to promote prudent use of antimicrobials are collectively referred to as antimicrobial stewardship programmes (ASPs). ASPs aim to ensure effective treatments for patients with infection, whilst reducing unnecessary or inappropriate antimicrobial use { ADDIN EN.CITE <EndNote><Cite><Author>Bailey</Author><Year>2015</Year><RecNum>20</RecNum><DisplayText>[4]</DisplayText><record><rec-number>20</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">20</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Bailey, Chantelle</author><author>Tully, Mary</author><author>Cooke, Jonathan</author></authors></contributors><titles><title>Perspectives of clinical microbiologists on antimicrobial stewardship programmes within NHS trusts in England</title><secondary-title>Antimicrobial resistance and infection control</secondary-title></titles><pages>1</pages><volume>4</volume><number>1</number><dates><year>2015</year></dates><isbn>2047-2994</isbn><urls></urls></record></Cite></EndNote>}. There is accumulating evidence that ASPs are safe and effective { ADDIN EN.CITE { ADDIN EN.CITE.DATA }}. The most recent Cochrane review of 221 studies of interventions to improve antibiotic prescribing practices for hospital inpatients reported high-certainty evidence that ASPs can effectively increase compliance with antimicrobial policies, reduce length of hospital admissions, and duration of antibiotic treatment, without increasing mortality { ADDIN EN.CITE <EndNote><Cite><Author>Davey</Author><Year>2017</Year><RecNum>45</RecNum><DisplayText>[11]</DisplayText><record><rec-number>45</rec-number><foreign-keys><key app="EN" db-

id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508152913">45</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Davey, Peter</author><author>Marwick, Charis A</author><author>Scott, Claire L</author><author>Charani, Esmita</author><author>McNeil, Kirsty</author><author>Brown, Erwin</author><author>Gould, Ian M</author><author>Ramsay, Craig R</author><author>Michie, Susan</author></authors></contributors><titles><title>Interventions to improve antibiotic prescribing practices for hospital inpatients</title><secondary-title>The Cochrane Library</secondary-title></titles><periodical><full-title>The Cochrane Library</full-title></periodical><dates><year>2017</year></dates><isbn>1465-1858</isbn><urls></urls></record></Cite></EndNote>}.</EndNote><Cite><Author>Davey</Author><Year>2017</Year><RecNum>45</RecNum><DisplayText>[11]</DisplayText><record><rec-number>45</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508152913">45</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Davey, Peter</author><author>Marwick, Charis A</author><author>Scott, Claire L</author><author>Charani, Esmita</author><author>McNeil, Kirsty</author><author>Brown, Erwin</author><author>Gould, Ian M</author><author>Ramsay, Craig R</author><author>Michie, Susan</author></authors></contributors><titles><title>Interventions to improve antibiotic prescribing practices for hospital inpatients</title><secondary-title>The Cochrane Library</secondary-title></titles><periodical><full-title>The Cochrane Library</full-title></periodical><dates><year>2017</year></dates><isbn>1465-1858</isbn><urls></urls></record></Cite></EndNote>}. For example, a key conclusion from the Cochrane review was that few interventions employed behavioural theory or behaviour change

techniques { ADDIN EN.CITE

<EndNote><Cite><Author>Davey</Author><Year>2017</Year><RecNum>45</RecNum><DisplayText>[11, 12]</DisplayText><record><rec-number>45</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508152913">45</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Davey, Peter</author><author>Marwick, Charis A</author><author>Scott, Claire L</author><author>Charani, Esmita</author><author>McNeil, Kirsty</author><author>Brown, Erwin</author><author>Gould, Ian M</author><author>Ramsay, Craig R</author><author>Michie, Susan</author></authors></contributors><titles><title>Interventions to improve antibiotic prescribing practices for hospital inpatients</title><secondary-title>The Cochrane Library</secondary-title></titles><periodical><full-title>The Cochrane Library</full-title></periodical><dates><year>2017</year></dates><isbn>1465-1858</isbn><urls></urls></record></Cite><Cite><Author>Davey</Author><Year>2015</Year><RecNum>44</RecNum><record><rec-number>44</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508152886">44</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Davey, Peter</author><author>Peden, Claire</author><author>Charani, Esmita</author><author>Marwick, Charis</author><author>Michie, Susan</author></authors></contributors><titles><title>Time for action—Improving the design and reporting of behaviour change interventions for antimicrobial stewardship in hospitals: Early findings from a systematic review</title><secondary-title>International journal of antimicrobial agents</secondary-title></titles><periodical><full-title>International journal of antimicrobial agents</full-title></periodical><pages>203-212</pages><volume>45</volume><number>3</number><dates><year>2015</year></dates><isbn>0924-8579</isbn><urls></urls></record></Cite></EndNote>}. While biomedical sciences are often the primary drivers of healthcare, other disciplines also have an important role in helping change practices and behaviours that influence health { ADDIN EN.CITE

<EndNote><Cite><Author>Campaign for Social Science</Author><Year>2017</Year><RecNum>46</RecNum><DisplayText>[13]</DisplayText>

<record><rec-number>46</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508153626">46</key></foreign-keys><ref-type name="Report">27</ref-type><contributors><authors><author>Campaign for Social Science, </author></authors><tertiary-authors><author>SAGE Publications Ltd</author></tertiary-authors></contributors><titles><title>The Health of People: How the social sciences can improve population health </title></titles><number>ISBN 978-1-47398-945-0</number><dates><year>2017</year></dates><pub-location>London, UK </pub-location><urls></urls></record></Cite></EndNote>}. Indeed, variation in patterns of antibiotic usage persist, that are unlikely to be explained by biomedical mechanisms alone { ADDIN EN.CITE <EndNote><Cite><Author>Hulscher</Author><Year>2010</Year><RecNum>14</RecNum><DisplayText>[2, 3]</DisplayText><record><rec-number>14</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">14</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Hulscher, Marlies EIJL</author><author>Grol, Richard PTM</author><author>van der Meer, Jos WM</author></authors></contributors><titles><title>Antibiotic prescribing in hospitals: a social and behavioural scientific approach</title><secondary-title>The Lancet infectious diseases</secondary-title></titles><pages>167-175</pages><volume>10</volume><number>3</number><dates><year>2010</year></dates><isbn>1473-3099</isbn><urls></urls></record></Cite><Cite><Author>Cars</Author><Year>2001</Year><RecNum>37</RecNum><record><rec-number>37</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508152557">37</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Cars, Otto</author><author>Mölstad, Sigvard</author><author>Melanders, Arne</author></authors></contributors><titles><title>Variation in antibiotic use in the European Union</title><secondary-title>The Lancet</secondary-title></titles><periodical><full-title>The lancet</full-title></periodical><pages>1851-1853</pages><volume>357</volume><number>9271</number><dates><year>2001</year></dates>

<isbn>0140-6736</isbn><urls></urls></record></Cite></EndNote>}. Behaviour change is also key to tackling the growing problem of antimicrobial resistance, in terms of reducing inappropriate antibiotic use and preventing infection { ADDIN EN.CITE <EndNote><Cite><Author>Davey</Author><Year>2015</Year><RecNum>44</RecNum><DisplayText>[12]</DisplayText><record><rec-number>44</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508152886">44</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Davey, Peter</author><author>Peden, Claire</author><author>Charani, Esmita</author><author>Marwick, Charis</author><author>Michie, Susan</author></authors></contributors><titles><title>Time for action—Improving the design and reporting of behaviour change interventions for antimicrobial stewardship in hospitals: Early findings from a systematic review</title><secondary-title>International journal of antimicrobial agents</secondary-title></titles><periodical><full-title>International journal of antimicrobial agents</full-title></periodical><pages>203-212</pages><volume>45</volume><number>3</number><dates><year>2015</year></dates><isbn>0924-8579</isbn><urls></urls></record></Cite></EndNote>}. Despite this, systematic reviews of ASPs as well as a recent report by the Department of Health and Social Care and Public Health in England have shown that behavioural and social influences are often not given due consideration in the design and evaluations of ASPs { ADDIN EN.CITE { ADDIN EN.CITE.DATA } }.

There have thus been calls for the urgent need to adopt a multidisciplinary approach to antimicrobial stewardship, involving relevant expertise from the behavioural and social sciences { ADDIN EN.CITE <EndNote><Cite><Author>Tonkin-Crine</Author><Year>2015</Year><RecNum>47</RecNum><DisplayText>[15]</DisplayText><record><rec-number>47</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508153925">47</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Tonkin-Crine, Sarah</author><author>Walker, Ann Sarah</author><author>Butler, Chris C</author></authors></contributors><titles><title>Contribution of behavioural science to antibiotic

stewardship</title><secondary-title>BMJ</secondary-title></titles><periodical><full-
title>Bmj</full-
title></periodical><pages>h3413</pages><volume>350</volume><dates><year>2015</year></date
s><isbn>1756-1833</isbn><urls></urls></record></Cite></EndNote>}. Behavioural and social
sciences cover a wide range of academic disciplines and research specialities, including but not limited
to: psychology, sociology, anthropology, economics, and political science { ADDIN EN.CITE
<EndNote><Cite><Author>Campaign for Social
Science</Author><Year>2017</Year><RecNum>46</RecNum><DisplayText>[13]</DisplayText>
<record><rec-number>46</rec-number><foreign-keys><key app="EN" db-
id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508153626">46</key></foreign-
keys><ref-type name="Report">27</ref-type><contributors><authors><author>Campaign for Social
Science, </author></authors><tertiary-authors><author>SAGE Publications Ltd</author></tertiary-
authors></contributors><titles><title>The Health of People: How the social sciences can improve
population health </title></titles><number>ISBN 978-1-47398-945-
0</number><dates><year>2017</year></dates><pub-location>London, UK </pub-
location><urls></urls></record></Cite></EndNote>}. Collectively, such disciplines provide theories,
models, and methods for a more comprehensive and coherent approach to behaviour and behaviour
change, which take into account the wide-ranging contextual, organisational and interpersonal
determinants of behaviour in order to explain why people behave in certain ways { ADDIN EN.CITE
<EndNote><Cite><Author>Campaign for Social
Science</Author><Year>2017</Year><RecNum>46</RecNum><DisplayText>[13]</DisplayText>
<record><rec-number>46</rec-number><foreign-keys><key app="EN" db-
id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508153626">46</key></foreign-
keys><ref-type name="Report">27</ref-type><contributors><authors><author>Campaign for Social
Science, </author></authors><tertiary-authors><author>SAGE Publications Ltd</author></tertiary-
authors></contributors><titles><title>The Health of People: How the social sciences can improve
population health </title></titles><number>ISBN 978-1-47398-945-
0</number><dates><year>2017</year></dates><pub-location>London, UK </pub-

location><urls></urls></record></Cite></EndNote>}. Thereby representing an alternative, but complementary approach to large scale quality improvement thinking and practice { ADDIN EN.CITE <EndNote><Cite><Author>Bate</Author><Year>2004</Year><RecNum>29</RecNum><DisplayText>[17]</DisplayText><record><rec-number>29</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72xfawpt2d9r" timestamp="0">29</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Bate, Paul</author><author>Robert, Glenn</author><author>Bevan, Helen</author></authors></contributors><titles><title>The next phase of healthcare improvement: what can we learn from social movements?</title><secondary-title>Quality and Safety in Health Care</secondary-title></titles><pages>62-66</pages><volume>13</volume><number>1</number><dates><year>2004</year></dates><isbn>2044-5423</isbn><urls></urls></record></Cite></EndNote>}.

In this paper, we discuss the potential means by which behavioural and social sciences can contribute towards driving sustainable behaviour change in antimicrobial prescribing practice. We focus on four key elements of the process of developing and evaluating complex behaviour change interventions: 1) defining the problem in behavioural terms and understanding current behaviour in context; 2) adopting a theory-driven, systematic approach to intervention design; 3) investigating implementation and sustainability of interventions in practice; and 4) maximising learning through evidence synthesis and detailed intervention reporting. We discuss antimicrobial stewardship across sectors, including secondary care, primary care, and other clinical areas where practical implementation and behaviour change concerns have been raised.

1. Defining the problem in behavioural terms and understanding current behaviour in context

Interventions to change healthcare professional behaviours are often designed without an explicit rationale for the selection of a specific intervention strategy { ADDIN EN.CITE <EndNote><Cite><Author>Michie</Author><Year>2004</Year><RecNum>5</RecNum><DisplayText>[18]</DisplayText><record><rec-number>5</rec-number><foreign-keys><key app="EN" db-

id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">5</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Michie, Susan</author><author>Abraham, Charles</author></authors></contributors><titles><title>Interventions to change health behaviours: evidence-based or evidence-inspired?</title><secondary-title>Psychology & Health</secondary-title></titles><pages>29-49</pages><volume>19</volume><number>1</number><dates><year>2004</year></dates><isbn>0887-0446</isbn><urls></urls></record></Cite></EndNote>}. Rather, interventions are frequently designed on the basis of intuitive ‘hunches’ or ‘best guesses’ of what needs to change { ADDIN EN.CITE <EndNote><Cite><Author>Colquhoun</Author><Year>2013</Year><RecNum>49</RecNum><DisplayText>[19]</DisplayText><record><rec-number>49</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508154972">49</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Colquhoun, Heather</author><author>Grimshaw, Jeremy</author><author>Wensing, Michel</author></authors></contributors><titles><title>Mapping KT interventions to barriers and facilitators</title><secondary-title>Knowledge Translation in Health Care: Moving from Evidence to Practice</secondary-title></titles><periodical><full-title>Knowledge Translation in Health Care: Moving from Evidence to Practice</full-title></periodical><pages>137-149</pages><dates><year>2013</year></dates><isbn>1118413555</isbn><urls></urls></record></Cite></EndNote>}. Often these represent a set of arguably naïve assumptions that dissemination of guidelines, introduction of new policies, or delivery of education will be sufficient to enable sustained behaviour change { ADDIN EN.CITE <EndNote><Cite><Author>Davey</Author><Year>2015</Year><RecNum>32</RecNum><DisplayText>[20, 21]</DisplayText><record><rec-number>32</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">32</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Davey,

Peter

The 2015 Garrod Lecture: Why is improvement difficult?

Journal of Antimicrobial Chemotherapy

2931-

2944

70

11

2015

bn0305-

7453

Gabbay

2004

50

50

fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508155049">50

Journal Article">17

Gabbay, John

le May, Andrée

Evidence based guidelines or collectively constructed “mindlines?” Ethnographic study of knowledge management in primary care

Bmj

Bmj

1013

329

7473

2004

0959-8138

}.</EndNote>.

However, one would not prescribe a particular medication without first assessing patient symptoms, and using this diagnosis as a basis for selecting the treatment that is most likely to be effective. Similarly, a key recommendation from the behavioural and social sciences is that interventions to change behaviour should also be designed on the basis of a thorough ‘behavioural diagnosis’ of why behaviours are as they are and what needs to change in order to bring about the desired behaviour {

ADDIN EN.CITE

Michie

2014

51

51

fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508155178">51

Journal Article">17

Susan

Atkins,

Lou

West,

Robert

The behaviour change wheel: a guide to designing interventions

Needed: physician leaders

title></titles><periodical><full-title>Needed: physician leaders</full-
 title></periodical><volume>26</volume><dates><year>2014</year></dates><urls></urls></record
 ></Cite></EndNote>}.
 { ADDIN EN.CITE

This is particularly important for antimicrobial stewardship - an arguably highly complex set of behaviours. It involves multiple actions, performed at different time points across the care continuum, including: adhering to guidelines, assessing benefit/risk, decision-making around initiation (drug choice, route, dose, duration, and timely drug administration) and review (switching or stopping) of treatment

<EndNote><Cite><Author>Davey</Author><Year>2015</Year><RecNum>44</RecNum><Display
 Text>[12]</DisplayText><record><rec-number>44</rec-number><foreign-keys><key app="EN" db-
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 Charis</author><author>Michie, Susan</author></authors></contributors><titles><title>Time for
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 of antimicrobial agents</full-title></periodical><pages>203-
 212</pages><volume>45</volume><number>3</number><dates><year>2015</year></dates><isbn
 >0924-8579</isbn><urls></urls></record></Cite></EndNote>}. Moreover, antimicrobial stewardship

is an inter-professional effort involving a range of healthcare professionals from different clinical specialties and of different levels of seniority (e.g. senior and junior physicians, nurses, pharmacists) {
 ADDIN EN.CITE

<EndNote><Cite><Author>Bailey</Author><Year>2015</Year><RecNum>20</RecNum><Display
 Text>[4]</DisplayText><record><rec-number>20</rec-number><foreign-keys><key app="EN" db-
 id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">20</key></foreign-keys><ref-type
 name="Journal Article">17</ref-type><contributors><authors><author>Bailey,

Chantelle</author><author>Tully, Mary</author><author>Cooke, Jonathan</author></authors></contributors><titles><title>Perspectives of clinical microbiologists on antimicrobial stewardship programmes within NHS trusts in England</title><secondary-title>Antimicrobial resistance and infection control</secondary-title></titles><pages>1</pages><volume>4</volume><number>1</number><dates><year>2015</year></dates><isbn>2047-2994</isbn><urls></urls></record></Cite></EndNote>}. The influences on these different behaviours are likely to be wide-ranging and to vary within and across different healthcare professionals, and different organisations across sectors of health care delivery { ADDIN EN.CITE

<EndNote><Cite><Author>Chaves</Author><Year>2014</Year><RecNum>23</RecNum><DisplayText>[23]</DisplayText><record><rec-number>23</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">23</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Chaves, NJ</author><author>Cheng, AC</author><author>Runnegar, Naomi</author><author>Kirschner, Jennifer</author><author>Lee, Trent</author><author>Busing, Kirsty</author></authors></contributors><titles><title>Analysis of knowledge and attitude surveys to identify barriers and enablers of appropriate antimicrobial prescribing in three Australian tertiary hospitals</title><secondary-title>Internal medicine journal</secondary-title></titles><pages>568-574</pages><volume>44</volume><number>6</number><dates><year>2014</year></dates><isbn>1445-5994</isbn><urls></urls></record></Cite></EndNote>}; emphasising the need for a tailored approach to improvement { ADDIN EN.CITE

<EndNote><Cite><Author>Hulscher</Author><Year>2010</Year><RecNum>14</RecNum><DisplayText>[2]</DisplayText><record><rec-number>14</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">14</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Hulscher, Marlies EIJL</author><author>Grol, Richard PTM</author><author>van der Meer, Jos WM</author></authors></contributors><titles><title>Antibiotic prescribing in hospitals: a social and behavioural scientific approach</title><secondary-title>The Lancet infectious diseases</secondary-

title></titles><pages>167-

175</pages><volume>10</volume><number>3</number><dates><year>2010</year></dates><isbn>1473-3099</isbn><urls></urls></record></Cite></EndNote>}.
<EndNote><Cite><Author>Michie</Author><Year>2014</Year><RecNum>51</RecNum><DisplayText>[22, 24]</DisplayText><record><rec-number>51</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508155178">51</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Michie, Susan</author><author>Atkins, Lou</author><author>West, Robert</author></authors></contributors><titles><title>The behaviour change wheel: a guide to designing interventions</title><secondary-title>Needed: physician leaders</secondary-title></titles><periodical><full-title>Needed: physician leaders</full-title></periodical><volume>26</volume><dates><year>2014</year></dates><urls></urls></record></Cite><Cite><Author>Atkins</Author><Year>2013</Year><RecNum>31</RecNum><record><rec-number>31</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">31</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Atkins, Lou</author><author>Michie, Susan</author></authors></contributors><titles><title>Changing eating behaviour: what can we learn from behavioural science?</title><secondary-title>Nutrition Bulletin</secondary-title></titles><pages>30-

Therefore, the behavioural and social sciences recommend that an essential first step is to be clear as to whose and which behaviours are being targeted for change. Vaguely specified target behaviours, such as ‘infection control’ do not provide the behavioural specificity and precision required for an informative behavioural analysis or targeted intervention { ADDIN EN.CITE

<EndNote><Cite><Author>Michie</Author><Year>2014</Year><RecNum>51</RecNum><DisplayText>[22, 24]</DisplayText><record><rec-number>51</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508155178">51</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Michie, Susan</author><author>Atkins, Lou</author><author>West, Robert</author></authors></contributors><titles><title>The behaviour change wheel: a guide to designing interventions</title><secondary-title>Needed: physician leaders</secondary-title></titles><periodical><full-title>Needed: physician leaders</full-title></periodical><volume>26</volume><dates><year>2014</year></dates><urls></urls></record></Cite><Cite><Author>Atkins</Author><Year>2013</Year><RecNum>31</RecNum><record><rec-number>31</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">31</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Atkins, Lou</author><author>Michie, Susan</author></authors></contributors><titles><title>Changing eating behaviour: what can we learn from behavioural science?</title><secondary-title>Nutrition Bulletin</secondary-title></titles><pages>30-

35</pages><volume>38</volume><number>1</number><dates><year>2013</year></dates><isbn>1467-3010</isbn><urls></urls></record></Cite></EndNote>}. Rather, it is necessary to describe the ‘problem’ of interest as precisely as possible in behavioural terms, that is: *who*, needs to do *what* differently, to *whom*, where and *when* { ADDIN EN.CITE

<EndNote><Cite><Author>Michie</Author><Year>2014</Year><RecNum>51</RecNum><DisplayText>[22]</DisplayText><record><rec-number>51</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508155178">51</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Michie, Susan</author><author>Atkins, Lou</author><author>West, Robert</author></authors></contributors><titles><title>The behaviour change wheel: a guide to designing interventions</title><secondary-title>Needed: physician leaders</secondary-title></titles><periodical><full-title>Needed: physician leaders</full-title></periodical><volume>26</volume><dates><year>2014</year></dates><urls></urls></record></Cite></EndNote>}. A behaviourally specific example in the context of stewardship is: ‘Surgeons

[*who*] working on the cardiac surgery ward [*where*] stopping antibiotics [*what*] 24 hours after surgery [*when*] for coronary artery bypass graft patients [*whom*] { ADDIN EN.CITE

<EndNote><Cite><Author>Sun</Author><Year>2011</Year><RecNum>37</RecNum><DisplayText>[25]</DisplayText><record><rec-number>37</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="1525863915">37</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Sun, Tzong-Bor</author><author>Chao, Shen-Feng</author><author>Chang, Bee-Song</author><author>Chen, Tsung-Ying</author><author>Gao, Pay-Yu</author><author>Shyr, Ming-Hwang</author></authors></contributors><titles><title>Quality improvements of antimicrobial prophylaxis in coronary artery bypass grafting</title><secondary-title>Journal of Surgical Research</secondary-title></titles><periodical><full-title>Journal of Surgical Research</full-title></periodical><pages>329-

335</pages><volume>167</volume><number>2</number><dates><year>2011</year></dates><isbn>0022-4804</isbn><urls></urls></record></Cite></EndNote>}. Such more precisely specified behaviours are also easier to measure, and therefore offer a baseline and metric for evaluating the success of an intervention { ADDIN EN.CITE

<EndNote><Cite><Author>Atkins</Author><Year>2013</Year><RecNum>31</RecNum><DisplayText>[24]</DisplayText><record><rec-number>31</rec-number><foreign-keys><key app="EN"

db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">31</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Atkins, Lou</author><author>Michie, Susan</author></authors></contributors><titles><title>Changing eating behaviour: what can we learn from behavioural science?</title><secondary-title>Nutrition Bulletin</secondary-title></titles><pages>30-35</pages><volume>38</volume><number>1</number><dates><year>2013</year></dates><isbn>1467-3010</isbn><urls></urls></record></Cite></EndNote>}.</p></div>
<div data-bbox="114 302 886 410" data-label="Text">
<p>Conducting a behavioural diagnosis is facilitated by the use of theory. Clinical practice is a form of human behaviour, which can be understood through conducting empirical research and the application of theories from the behavioural and social sciences that have been used to explain or predict behaviour in the general population { ADDIN EN.CITE</p></div>
<div data-bbox="114 422 886 769" data-label="Text">
<p><EndNote><Cite><Author>Michie</Author><Year>2005</Year><RecNum>54</RecNum><DisplayText>[26, 27]</DisplayText><record><rec-number>54</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508158474">54</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Michie, S</author><author>Johnston, Marie</author><author>Abraham, Charles</author><author>Lawton, R</author><author>Parker, D</author><author>Walker, A</author></authors></contributors><titles><title>Making psychological theory useful for implementing evidence based practice: a consensus approach</title><secondary-title>BMJ Quality & Safety</secondary-title></titles><periodical><full-title>BMJ quality & safety</full-title></periodical><pages>26-33</pages><volume>14</volume><number>1</number><dates><year>2005</year></dates><isbn>2044-5415</isbn><urls></urls></record></Cite><Cite><Author>Hrisos</Author><Year>2008</Year><RecNum>55</RecNum><record><rec-number>55</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508158530">55</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Hrisos,</p></div>
<div data-bbox="651 921 886 939" data-label="Page-Footer">
<p>{ PAGE * MERGEFORMAT }</p></div>

Susan</author><author>Eccles, Martin</author><author>Johnston, Marie</author><author>Francis, Jill</author><author>Kaner, Eileen FS</author><author>Steen, Nick</author><author>Grimshaw, Jeremy</author></authors></contributors><titles><title>Developing the content of two behavioural interventions: using theory-based interventions to promote GP management of upper respiratory tract infection without prescribing antibiotics# 1</title><secondary-title>BMC Health Services Research</secondary-title></titles><periodical><full-title>BMC Health Services Research</full-title></periodical><pages>11</pages><volume>8</volume><number>1</number><dates><year>2008</year></dates><isbn>1472-6963</isbn><urls></urls></record></Cite></EndNote>}. However, though multiple behaviour change theories are available, systematic procedures for selecting one theory over another are only now beginning to emerge { ADDIN EN.CITE <EndNote><Cite><Author>Birken</Author><Year>2017</Year><RecNum>36</RecNum><DisplayText>[28]</DisplayText><record><rec-number>36</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72xfawpt2d9r" timestamp="1518254251">36</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Birken, Sarah A</author><author>Powell, Byron J</author><author>Shea, Christopher M</author><author>Haines, Emily R</author><author>Kirk, M Alexis</author><author>Leeman, Jennifer</author><author>Rohweder, Catherine</author><author>Damschroder, Laura</author><author>Presseau, Justin</author></authors></contributors><titles><title>Criteria for selecting implementation science theories and frameworks: results from an international survey</title><secondary-title>Implementation Science</secondary-title></titles><periodical><full-title>Implementation Science</full-title></periodical><pages>124</pages><volume>12</volume><number>1</number><dates><year>2017</year></dates><isbn>1748-5908</isbn><urls></urls></record></Cite></EndNote>}.</p>
</div>

<p>Moreover, many non-specialists find the whole area ‘mystifying’ { ADDIN EN.CITE <EndNote><Cite><Author>Davidoff</Author><Year>2015</Year><RecNum>10</RecNum><DisplayText>[29]</DisplayText><record><rec-number>10</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72xfawpt2d9r" timestamp="0">10</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Davidoff,</p>
</div>

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Frank</author><author>Dixon-Woods, Mary</author><author>Leviton, Laura</author><author>Michie, Susan</author></authors></contributors><titles><title>Demystifying theory and its use in improvement</title><secondary-title>BMJ quality & safety</secondary-title></titles><pages>bmjqs-2014-003627</pages><dates><year>2015</year></dates><isbn>2044-5423</isbn><urls></urls></record></Cite></EndNote>}.</p>
</div>
<div data-bbox="114 272 886 890" data-label="Text">
<p>In turn, behavioural and social scientists have invested in efforts to synthesise available theories and frameworks, in order to reduce complexity resulting from the overlap between individual theories, and increase the accessibility of theory. Two examples of such synthesis efforts are the COM-B model and the Theoretical Domains Framework (TDF), which were developed by synthesising a core set of 33 behaviour change theories (Figure 1; Table 1) { ADDIN EN.CITE { ADDIN EN.CITE.DATA }}. COM-B is a simple model of behaviour, which postulates that three basic pre-conditions must be met in order for behaviour to occur: an individual has to have the Capability (i.e. knowledge and skills), Motivation, and Opportunity (physical and social) to perform the behaviour { ADDIN EN.CITE</p>
<p><EndNote><Cite><Author>Michie</Author><Year>2011</Year><RecNum>25</RecNum><DisplayText>[30]</DisplayText><record><rec-number>25</rec-number><foreign-keys><key app="EN" db-id="fp2srrssqa52zvesf07p9zetsxa9a90w9wsw" timestamp="1525863931">25</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Michie, Susan</author><author>van Stralen, Maartje M</author><author>West, Robert</author></authors></contributors><titles><title>The behaviour change wheel: a new method for characterising and designing behaviour change interventions</title><secondary-title>Implementation science</secondary-title></titles><pages>42</pages><volume>6</volume><number>1</number><dates><year>2011</year></dates><isbn>1748-5908</isbn><urls></urls></record></Cite></EndNote>} (Figure 1). These COM-B components can be further elaborated into 14 Theoretical Domains, which represent the range of potential factors influencing behaviour (i.e. barriers/enablers). These range from individual knowledge, skills, memory, attention, decision-making, beliefs about capabilities and consequences,</p>
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<div data-bbox="651 921 886 939" data-label="Page-Footer">
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</div>

goals, and emotions, to broader physical and social contextual factors, including resource availability and social norms, professional boundaries/roles, etc. (Table 1).

[Figure 1 Here]

Both COM-B and the TDF has been applied to conduct behavioural diagnoses of ‘what needs to change’ for numerous clinical behaviours { ADDIN EN.CITE <EndNote><Cite><Author>Francis</Author><Year>2012</Year><RecNum>56</RecNum><DisplayText>[32]</DisplayText><record><rec-number>56</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508158964">56</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Francis, Jill J</author><author>O’Connor, Denise</author><author>Curran, Janet</author></authors></contributors><titles><title>Theories of behaviour change synthesised into a set of theoretical groupings: introducing a thematic series on the theoretical domains framework</title><secondary-title>Implementation Science</secondary-title></titles><periodical><full-title>Implementation Science</full-title></periodical><pages>35</pages><volume>7</volume><number>1</number><dates><year>2012</year></dates><isbn>1748-5908</isbn><urls></urls></record></Cite></EndNote>}. In the context of antimicrobial stewardship, the TDF has been used to design surveys and semi-structured interview topic guides to explore the factors influencing antimicrobial prescribing across various healthcare settings, including hospitals, general dental practice and long-term cares facilities { ADDIN EN.CITE { ADDIN EN.CITE.DATA }}. Table 1 illustrates examples of barriers/enablers within each of 14 TDF domains using findings from these studies; representing the role that each domain plays in hindering and/or enabling changes to antimicrobial prescribing.

[Table 1 here]

It is particularly critical to recognise that individual behaviour occurs in a wider social and cultural context. A number of studies have applied social science methodologies and analytical approaches to study antimicrobial prescribing { ADDIN EN.CITE <EndNote><Cite><Author>Rawson</Author><Year>2016</Year><RecNum>52</RecNum><Displ

ayText>[36, 37]</DisplayText><record><rec-number>52</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508156336">52</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Rawson, Timothy Miles</author><author>Charani, Esmita</author><author>Moore, Luke Stephen Prockter</author><author>Hernandez, Bernard</author><author>Castro-Sánchez, Enrique</author><author>Herrero, Pau</author><author>Georgiou, Pantelis</author><author>Holmes, Alison Helen</author></authors></contributors><titles><title>Mapping the decision pathways of acute infection management in secondary care among UK medical physicians: a qualitative study</title><secondary-title>BMC medicine</secondary-title></titles><periodical><full-title>BMC medicine</full-title></periodical><pages>208</pages><volume>14</volume><number>1</number><dates><year>2016</year></dates><isbn>1741-7015</isbn><urls></urls></record></Cite><Cite><Author>Charani</Author><Year>2013</Year><RecNum>18</RecNum><record><rec-number>18</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">18</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Charani, Esmita</author><author>Castro-Sanchez, E</author><author>Sevdalis, N</author><author>Kyratsis, Y</author><author>Drumright, L</author><author>Shah, N</author><author>Holmes, A</author></authors></contributors><titles><title>Understanding the determinants of antimicrobial prescribing within hospitals: the role of “prescribing etiquette”</title><secondary-title>Clinical Infectious Diseases</secondary-title></titles><pages>188-196</pages><volume>57</volume><number>2</number><dates><year>2013</year></dates><isbn>1058-4838</isbn><urls></urls></record></Cite></EndNote>}, to diagnose the socio-cultural influences on behaviour. Charani et al’s study of prescribing in secondary care { ADDIN EN.CITE <EndNote><Cite><Author>Charani</Author><Year>2013</Year><RecNum>18</RecNum><DisplayText>[37]</DisplayText><record><rec-number>18</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">18</key></foreign-keys><ref-type

name="Journal Article">17</ref-type><contributors><authors><author>Charani, Esmita</author><author>Castro-Sanchez, E</author><author>Sevdalis, N</author><author>Kyratsis, Y</author><author>Drumright, L</author><author>Shah, N</author><author>Holmes, A</author></authors></contributors><titles><title>Understanding the determinants of antimicrobial prescribing within hospitals: the role of “prescribing etiquette”</title><secondary-title>Clinical Infectious Diseases</secondary-title></titles><pages>188-196</pages><volume>57</volume><number>2</number><dates><year>2013</year></dates><isbn>1058-4838</isbn><urls></urls></record></Cite></EndNote>}, showed that antimicrobial prescribing decisions are heavily shaped by hierarchies and ‘prescribing etiquette’- a set of unwritten social rules that healthcare professionals recognise and abide by – that over-rule policy and guidelines

{ ADDIN EN.CITE <EndNote><Cite><Author>Charani</Author><Year>2013</Year><RecNum>18</RecNum><DisplayText>[37]</DisplayText><record><rec-number>18</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">18</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Charani, Esmita</author><author>Castro-Sanchez, E</author><author>Sevdalis, N</author><author>Kyratsis, Y</author><author>Drumright, L</author><author>Shah, N</author><author>Holmes, A</author></authors></contributors><titles><title>Understanding the determinants of antimicrobial prescribing within hospitals: the role of “prescribing etiquette”</title><secondary-title>Clinical Infectious Diseases</secondary-title></titles><pages>188-196</pages><volume>57</volume><number>2</number><dates><year>2013</year></dates><isbn>1058-4838</isbn><urls></urls></record></Cite></EndNote>}. Similarly, a recent qualitative study of antimicrobial decision making in surgery { ADDIN EN.CITE <EndNote><Cite><Author>Charani</Author><Year>2017</Year><RecNum>67</RecNum><DisplayText>[38]</DisplayText><record><rec-number>67</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1518175222">67</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Charani, E</author><author>Tarrant, Carolyn</author><author>Moorthy, K</author><author>Sevdalis,

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N</author><author>Brennan, L</author><author>Holmes, AH</author></authors></contributors><titles><title>Understanding antibiotic decision making in surgery—a qualitative analysis</title><secondary-title>Clinical Microbiology and Infection</secondary-title></titles><periodical><full-title>Clinical Microbiology and Infection</full-title></periodical><pages>752-

760</pages><volume>23</volume><number>10</number><dates><year>2017</year></dates><isbn>1198-743X</isbn></urls></urls></record></Cite></EndNote>} reported that surgical teams often faced multiple competing priorities alongside resource constraints, resulting in the responsibility for, and communication about, antimicrobial decision making becoming diffuse and uncoordinated. Understanding how different clinical teams operate, and what demands they must face given available resources, is key to designing ASPs that not only target drivers of individual behaviour change, but also address the underlying socio-cultural factors that shape behaviour.

Collectively, the evidence generated by these studies illustrate that there is no single, uniform influence on antimicrobial prescribing. Rather, these findings support the notion that antimicrobial prescribing is a complex behaviour influenced by an equally complex combination of factors { ADDIN EN.CITE <EndNote><Cite><Author>Rodrigues</Author><Year>2013</Year><RecNum>70</RecNum><DisplayText>[39]</DisplayText><record><rec-number>70</rec-number><foreign-keys><key

app="EN" db-id="255wf9pr9wpd0eeafq5sfx9vetfvw9sfpas" timestamp="1508254952">70</key></foreign-keys><ref-type name="Journal Article">17</ref-type></contributors><authors><author>Rodrigues, António Teixeira</author><author>Roque, Fátima</author><author>Falcão, Amílcar</author><author>Figueiras, Adolfo</author><author>Herdeiro, Maria Teresa</author></authors></contributors><titles><title>Understanding physician antibiotic prescribing behaviour: a systematic review of qualitative studies</title><secondary-title>International journal of antimicrobial agents</secondary-title></titles><periodical><full-title>International journal of antimicrobial agents</full-title></periodical><pages>203-

212</pages><volume>41</volume><number>3</number><dates><year>2013</year></dates><isbn>0924-8579</isbn><urls></urls></record></Cite></EndNote>}.
<EndNote><Cite><Author>Michie</Author><Year>2008</Year><RecNum>61</RecNum><DisplayText>[40]</DisplayText><record><rec-number>61</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508162635">61</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Michie, Susan</author><author>Johnston, Marie</author><author>Francis, Jill</author><author>Hardeman, Wendy</author><author>Eccles, Martin</author></authors></contributors><titles><title>From theory to intervention: mapping theoretically derived behavioural determinants to behaviour change techniques</title><secondary-title>Applied psychology</secondary-title></titles><periodical><full-title>Applied psychology</full-title></periodical><pages>660-680</pages><volume>57</volume><number>4</number><dates><year>2008</year></dates><isbn>1464-0597</isbn><urls></urls></record></Cite></EndNote>}. For instance, providing education around antimicrobial stewardship is only likely to be effective if the key barrier is a deficit in knowledge. Table 1 demonstrates that the factors influencing antibiotic prescribing extend beyond knowledge; highlighting the importance of considering additional intervention strategies and techniques that consider the broader social and environmental context.

2. Adopting a theory-driven, systematic approach to intervention design

Conducting such behavioural diagnoses of the underpinning factors that drive behaviour can inform the design of targeted interventions. Interventions are more likely to be effective if they are tailored to the context of interest, and include components that target the key influences on behaviour and behaviour change

{ ADDIN EN.CITE <EndNote><Cite><Author>Michie</Author><Year>2008</Year><RecNum>61</RecNum><DisplayText>[40]</DisplayText><record><rec-number>61</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508162635">61</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Michie, Susan</author><author>Johnston, Marie</author><author>Francis, Jill</author><author>Hardeman, Wendy</author><author>Eccles, Martin</author></authors></contributors><titles><title>From theory to intervention: mapping theoretically derived behavioural determinants to behaviour change techniques</title><secondary-title>Applied psychology</secondary-title></titles><periodical><full-title>Applied psychology</full-title></periodical><pages>660-680</pages><volume>57</volume><number>4</number><dates><year>2008</year></dates><isbn>1464-0597</isbn><urls></urls></record></Cite></EndNote>}. For instance, providing education around antimicrobial stewardship is only likely to be effective if the key barrier is a deficit in knowledge. Table 1 demonstrates that the factors influencing antibiotic prescribing extend beyond knowledge; highlighting the importance of considering additional intervention strategies and techniques that consider the broader social and environmental context.

The Medical Research Council (MRC) guidance for developing and evaluating complex interventions advocates taking a systematic, theoretically-based approach to intervention design { ADDIN EN.CITE <EndNote><Cite><Author>Craig</Author><Year>2008</Year><RecNum>7</RecNum><DisplayText>[41, 42]</DisplayText><record><rec-number>7</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">7</key></foreign-keys><ref-type

name="Journal Article">17</ref-type><contributors><authors><author>Craig, Peter</author><author>Dieppe, Paul</author><author>Macintyre, Sally</author><author>Michie, Susan</author><author>Nazareth, Irwin</author><author>Petticrew, Mark</author></authors></contributors><titles><title>Developing and evaluating complex interventions: the new Medical Research Council guidance</title><secondary-title>Bmj</secondary-title></titles><pages>a1655</pages><volume>337</volume><dates><year>2008</year></dates><isbn>0959-

8138</isbn><urls></urls></record></Cite><Cite><Author>Moore</Author><Year>2015</Year><RecNum>65</RecNum><record><rec-number>65</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508167967">65</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Moore, Graham F</author><author>Audrey, Suzanne</author><author>Barker, Mary</author><author>Bond, Lyndal</author><author>Bonell, Chris</author><author>Hardeman, Wendy</author><author>Moore, Laurence</author><author>O’Cathain, Alicia</author><author>Tinati, Tannaze</author><author>Wight, Daniel</author></authors></contributors><titles><title>Process evaluation of complex interventions: Medical Research Council guidance</title><secondary-title>bmj</secondary-title></titles><periodical><full-title>Bmj</full-

title></periodical><pages>h1258</pages><volume>350</volume><dates><year>2015</year></dates><isbn>1756-1833</isbn><urls></urls></record></Cite></EndNote>}. However, the guidance provides limited recommendations as to how to do this. The behavioural and social sciences offer a range of methods and recently developed, inter-related frameworks that aim to help intervention designers to systematically move from behavioural diagnosis to intervention development in a theoretically-informed way { ADDIN EN.CITE

<EndNote><Cite><Author>Michie</Author><Year>2014</Year><RecNum>51</RecNum><DisplayText>[22, 24]</DisplayText><record><rec-number>51</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508155178">51</key></foreign-keys><ref-type name="Journal Article">17</ref-

type><contributors><authors><author>Michie, Susan</author><author>Atkins, Lou</author><author>West, Robert</author></authors></contributors><titles><title>The behaviour change wheel: a guide to designing interventions</title><secondary-title>Needed: physician leaders</secondary-title></titles><periodical><full-title>Needed: physician leaders</full-title></periodical><volume>26</volume><dates><year>2014</year></dates><urls></urls></record></Cite><Cite><Author>Atkins</Author><Year>2013</Year><RecNum>31</RecNum><record><rec-number>31</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxawpt2d9r" timestamp="0">31</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Atkins, Lou</author><author>Michie, Susan</author></authors></contributors><titles><title>Changing eating behaviour: what can we learn from behavioural science?</title><secondary-title>Nutrition Bulletin</secondary-title></titles><pages>30-35</pages><volume>38</volume><number>1</number><dates><year>2013</year></dates><isbn>1467-3010</isbn><urls></urls></record></Cite></EndNote>}.
 For example, the Behaviour Change Wheel (Figure 2) { ADDIN EN.CITE

<EndNote><Cite><Author>Michie</Author><Year>2011</Year><RecNum>59</RecNum><DisplayText>[30]</DisplayText><record><rec-number>59</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508161927">59</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Michie, Susan</author><author>van Stralen, Maartje M</author><author>West, Robert</author></authors></contributors><titles><title>The behaviour change wheel: a new method for characterising and designing behaviour change interventions</title><secondary-title>Implementation science</secondary-title></titles><periodical><full-title>Implementation Science</full-title></periodical><pages>42</pages><volume>6</volume><number>1</number><dates><year>2011</year></dates><isbn>1748-5908</isbn><urls></urls></record></Cite></EndNote>} is an increasingly used behavioural science framework that was developed to promote a structured, theory-

and evidence-based approach to designing behaviour change interventions. In order to identify the type of intervention that is likely to be effective, it is important to consider the full range of options and techniques available and use a rational system for selecting from among them. This requires an appropriate method/framework for characterising or describing interventions and synergistically linking them to an understanding of the target behaviour. The BCW and associated behaviour change technique taxonomy offer such frameworks { ADDIN EN.CITE { ADDIN EN.CITE.DATA }}. The BCW was developed from a synthesis of 19 behaviour change frameworks. At the hub of the BCW is the COM-B model and Theoretical Domains Framework (Figure 2). These are surrounded by nine intervention functions (i.e. broad types of intervention strategies; e.g. environmental restructuring, enablement, persuasion), alongside seven policy domains to support intervention implementation (i.e. guidelines, legislation)

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<EndNote><Cite><Author>Michie</Author><Year>2011</Year><RecNum>25</RecNum><DisplayText>[30]</DisplayText><record><rec-number>25</rec-number><foreign-keys><key app="EN" db-id="fp2srrssqa52zvesf07p9zetsxa9a90w9wsw" timestamp="1525863931">25</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Michie, Susan</author><author>van Stralen, Maartje M</author><author>West, Robert</author></authors></contributors><titles><title>The behaviour change wheel: a new method for characterising and designing behaviour change interventions</title><secondary-title>Implementation science</secondary-title></titles><pages>42</pages><volume>6</volume><number>1</number><dates><year>2011</year></dates><isbn>1748-5908</isbn><urls></urls></record></Cite></EndNote>}. Intervention functions are made up of smaller component behaviour change techniques (e.g. goal setting, action planning, problem solving). The taxonomy defines 93 discrete behaviour change techniques, each with accompanying criteria for its operationalisation. As different functions and techniques are likely to be more or less effective in targeting different types of influences on behaviour, matrices have been developed based on expert-behavioural science consensus, which pair functions from the BCW and techniques from the taxonomy with the COM-B/TDF domains they are most likely to be effective in targeting.

[Figure 2 here]

These frameworks therefore interlink to form eight steps for moving systematically and synergistically from initial behavioural diagnosis to intervention design (Figure 3). Potentially all functions from the BCW could be relevant to improving stewardship, depending on what factors are shown to be driving stewardship related behaviours in a behavioural diagnosis. This appears to be the case; given the aforementioned studies that used the TDF to explore factors influencing antimicrobial prescribing identified at least one barriers/enablers across all 14 domains. This is illustrated in the examples provided in Table 2. whereby the aforementioned studies consulted the BCW and taxonomy to identify potential intervention functions and techniques that are likely to be most effective in addressing the key barriers and enablers identified by their behavioural diagnosis (Table 1) { ADDIN EN.CITE { ADDIN EN.CITE.DATA }}.

[Figure 3 here]

[Table 2 here]

Interventions will be more impactful if the socio-cultural context for behaviour is also considered. For example, Charani et al's { ADDIN EN.CITE <EndNote><Cite><Author>Charani</Author><Year>2017</Year><RecNum>67</RecNum><DisplayText>[38]</DisplayText><record><rec-number>67</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1518175222">67</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Charani, E</author><author>Tarrant, Carolyn</author><author>Moorthy, K</author><author>Sevdalis, N</author><author>Brennan, L</author><author>Holmes, AH</author></authors></contributors><titles><title>Understanding antibiotic decision making in surgery—a qualitative analysis</title><secondary-title>Clinical Microbiology and Infection</secondary-title></titles><periodical><full-title>Clinical Microbiology and Infection</full-

title></periodical><pages>752-

760</pages><volume>23</volume><number>10</number><dates><year>2017</year></dates><isbn>1198-743X</isbn><urls></urls></record></Cite></EndNote>} findings suggest that in order to optimise antimicrobial prescribing, intervention strategies need to engage specialties outside infection disease and microbiology, and to engage senior doctors and opinion leaders to engender a shift in norms and expectations. Local and national cultural influences on prescribing need to be initially understood, recognised, and subsequently incorporated into local policy and practice to bolster interventions targeting individual practice [26].

Although behavioural and social science theories, methods and frameworks have primarily been applied in such a ‘bottom-up’ approach to designing interventions, they also have value in refining existing interventions. Indeed, a common scenario in healthcare quality improvement is not that of ‘starting from scratch’ to design new interventions, but rather, of having existing interventions that have already been implemented in practice, yet have achieved only modest or inconsistent success, and may thus benefit from refinement. A pre-requisite for identifying potential refinements is fully specifying the current intervention and the behaviour change techniques it incorporates. For example, Steinmo et al. { ADDIN EN.CITE

<EndNote><Cite><Author>Steinmo</Author><Year>2015</Year><RecNum>7</RecNum><DisplayText>[44]</DisplayText><record><rec-number>7</rec-number><foreign-keys><key app="EN" db-id="255wf9pr9wpd0eeafq5sfx9vetfvw9sfpas" timestamp="1507028897">7</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Steinmo, Siri</author><author>Fuller, Christopher</author><author>Stone, Sheldon P</author><author>Michie, Susan</author></authors></contributors><titles><title>Characterising an implementation intervention in terms of behaviour change techniques and theory: the ‘Sepsis Six’ clinical care bundle</title><secondary-title>Implementation Science</secondary-title></titles><periodical><full-title>Implementation Science</full-title></periodical><pages>111</pages><volume>10</volume><number>1</number><dates><year>2015</year></dates><isbn>1748-5908</isbn><urls></urls></record></Cite></EndNote>} aimed to

improve a multi-component intervention to increase the implementation of a sepsis care bundle that had been implemented with moderate success within three pilot wards of a UK hospital. To specify the existing intervention, they observed the intervention being delivered and conducted a content analysis of the intervention materials; applying the BCW and taxonomy to characterise the intervention in terms of intervention functions and techniques. They found 19 behaviour change techniques (e.g. prompts/cues, instruction on how to perform the behaviour) and seven intervention functions (e.g. education, enablement, training) { ADDIN EN.CITE <EndNote><Cite><Author>Steinmo</Author><Year>2015</Year><RecNum>8</RecNum><DisplayText>[45]</DisplayText><record><rec-number>8</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">8</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Steinmo, Siri</author><author>Fuller, Christopher</author><author>Stone, Sheldon P</author><author>Michie, Susan</author></authors></contributors><titles><title>Characterising an implementation intervention in terms of behaviour change techniques and theory: the ‘Sepsis Six’ clinical care bundle</title><secondary-title>Implementation Science</secondary-title></titles><periodical><full-title>Implementation Science</full-title></periodical><pages>1</pages><volume>10</volume><number>1</number><dates><year>2015</year></dates><isbn>1748-5908</isbn><urls></urls></record></Cite></EndNote>}. They then used the TDF to conduct interviews with intervention designers, providers, and recipients to characterise the intervention’s potential theoretical mechanisms of action and barriers/enablers to its implementation. On the basis of their findings, they were able to propose a number of theory-based modifications to the intervention package, including: changes to the existing staff education programme to address fears about harming patients (e.g. with intravenous fluid) (i.e. behaviour change technique: ‘information about health consequences’), and provision of sepsis equipment bags to Night Coordinators, who previously reported lack of access to the necessary equipment as a key barrier (i.e. behaviour change technique: ‘adding objects to the environment’) { ADDIN EN.CITE <EndNote><Cite><Author>Steinmo</Author><Year>2016</Year><RecNum>9</RecNum><DisplayText>[46]</DisplayText><record><rec-number>9</rec-number><foreign-keys><key app="EN" db-

id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">9</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Steinmo, Siri H</author><author>Michie, Susan</author><author>Fuller, Christopher</author><author>Stanley, Sarah</author><author>Stapleton, Caitriona</author><author>Stone, Sheldon P</author></authors></contributors><titles><title>Bridging the gap between pragmatic intervention design and theory: using behavioural science tools to modify an existing quality improvement programme to implement “Sepsis Six”</title><secondary-title>Implementation Science</secondary-title></titles><periodical><full-title>Implementation Science</full-title></periodical><pages>1</pages><volume>11</volume><number>1</number><dates><year>2016</year></dates><isbn>1748-5908</isbn><urls></urls></record></Cite></EndNote>}.</p></div>
<div data-bbox="114 431 882 899" data-label="Text">
<p>Importantly, development of antimicrobial stewardship interventions can benefit from drawing on broader research that provides evidence of how to optimise particular types of behaviour change interventions. A frequently used strategy in ASPs is audit and feedback { ADDIN EN.CITE <EndNote><Cite><Author>Davey</Author><Year>2010</Year><RecNum>39</RecNum><DisplayText>[6]</DisplayText><record><rec-number>39</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508152709">39</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Davey, Peter</author><author>Sneddon, Jacqueline</author><author>Nathwani, Dilip</author></authors></contributors><titles><title>Overview of strategies for overcoming the challenge of antimicrobial resistance</title><secondary-title>Expert review of clinical pharmacology</secondary-title></titles><periodical><full-title>Expert review of clinical pharmacology</full-title></periodical><pages>667-686</pages><volume>3</volume><number>5</number><dates><year>2010</year></dates><isbn>1751-2433</isbn><urls></urls></record></Cite></EndNote>}, defined as ‘providing a summary of the clinical performance of healthcare provider(s) over a specified time period’ { ADDIN EN.CITE <EndNote><Cite><Author>Ivers</Author><Year>2012</Year><RecNum>2</RecNum><DisplayTe</div>
<div data-bbox="653 922 882 939" data-label="Page-Footer">
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4) targeted at behaviours where there is significant room for improvement (i.e. baseline performance of targeted clinical practice behaviours is low, < 75%, but stronger effects observed if less than < 25 % compliance); and 5) accompanied by explicit recommendations for changing practice (i.e. goals and action plans) { ADDIN EN.CITE <EndNote><Cite><Author>Ivers</Author><Year>2012</Year><RecNum>62</RecNum><DisplayText>[48]</DisplayText><record><rec-number>62</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508166044">62</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Ivers, Noah</author><author>Jamtvedt, Gro</author><author>Flottorp, Signe</author><author>Young, Jane M</author><author>Odgaard- Jensen, Jan</author><author>French, Simon D</author><author>O'Brien, Mary Ann</author><author>Johansen, Marit</author><author>Grimshaw, Jeremy</author><author>Oxman, Andrew D</author></authors></contributors><titles><title>Audit and feedback: effects on professional practice and healthcare outcomes</title><secondary-title>The Cochrane Library</secondary-title></titles><periodical><full-title>The Cochrane Library</full-title></periodical><dates><year>2012</year></dates><isbn>1465-1858</isbn></urls></urls></record></Cite></EndNote>}. Such findings represent a generalizable body of evidence from the broader behaviour change literature that intervention designers can draw upon to inform how best to deliver a particular type of intervention component or technique in the context of antimicrobial stewardship to maximise likely effectiveness.

There is growing evidence to support the effectiveness of antimicrobial stewardship interventions designed on the basis of behavioural theory and evidence. For example, one intervention based on Social Learning Theory aiming to increase primary care clinicians' motivation and confidence to change their prescribing practice resulted in significant reductions in all cause antibiotic prescribing in over one year, with no accompanying significant changes to hospital admissions, repeat consultations or costs { ADDIN EN.CITE <EndNote><Cite><Author>Tonkin-Crine</Author><Year>2015</Year><RecNum>47</RecNum><DisplayText>[15,

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yText>[51]</DisplayText><record><rec-number>63</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508167860">63</key></foreign-keys><ref-type name="Book">6</ref-type><contributors><authors><author>Linnan, Laura</author><author>Steckler, Allan</author></authors></contributors><titles><title>Process evaluation for public health interventions and research</title></titles><dates><year>2002</year></dates><publisher>Jossey-Bass San Francisco</publisher><isbn>0787959766</isbn><urls></urls></record></Cite></EndNote>}. They

are also highly context-dependent { ADDIN EN.CITE

<EndNote><Cite><Author>Squires</Author><Year>2015</Year><RecNum>64</RecNum><Displa

yText>[52]</DisplayText><record><rec-number>64</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508167893">64</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Squires, Janet E</author><author>Graham, Ian D</author><author>Hutchinson, Alison M</author><author>Michie, Susan</author><author>Francis, Jill J</author><author>Sales, Anne</author><author>Brehaut, Jamie</author><author>Curran, Janet</author><author>Ivers, Noah</author><author>Lavis, John</author></authors></contributors><titles><title>Identifying the domains of context important to implementation science: a study protocol</title><secondary-title>Implementation Science</secondary-title></titles><periodical><full-title>Implementation Science</full-

title></periodical><pages>135</pages><volume>10</volume><number>1</number><dates><year>2015</year></dates><isbn>1748-5908</isbn><urls></urls></record></Cite></EndNote>}. Combined, these factors increase an intervention's susceptibility to variable implementation. As such, once an intervention has been designed, it cannot be assumed that it will be faithfully and consistently delivered and responded to as intended when implemented on scale { ADDIN EN.CITE

<EndNote><Cite><Author>Moore</Author><Year>2015</Year><RecNum>65</RecNum><Displa

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Graham F</author><author>Audrey, Suzanne</author><author>Barker,
Mary</author><author>Bond, Lyndal</author><author>Bonell, Chris</author><author>Hardeman,
Wendy</author><author>Moore, Laurence</author><author>O’Cathain,
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title></periodical><pages>h1258</pages><volume>350</volume><dates><year>2015</year></date
s><isbn>1756-1833</isbn><urls></urls></record></Cite></EndNote>}. Nor can it be assumed that an

intervention that is shown to lead to initial changes in practice will sustain over the longer-term, or will
be equally effective when replicated in new settings. In one example, an evaluation of an educational
outreach antimicrobial stewardship intervention found an initial decrease in use of a target antibiotic;
however, after seven years the intervention was stopped due to resource constraints. Within two years
of the intervention ending antibiotic use and costs increased { ADDIN EN.CITE

<EndNote><Cite><Author>Standiford</Author><Year>2012</Year><RecNum>146</RecNum><Di
splayText>[53]</DisplayText><record><rec-number>146</rec-number><foreign-keys><key

app="EN" db-id="pravad92swxz04exa5evrp9pf9fextr9aww5"
timestamp="1488198899">146</key></foreign-keys><ref-type name="Journal Article">17</ref-

type><contributors><authors><author>Standiford, Harold C</author><author>Chan,
Shannon</author><author>Tripoli, Megan</author><author>Weekes,

Elizabeth</author><author>Forrest, Graeme

N</author></authors></contributors><titles><title>Antimicrobial stewardship at a large tertiary care
academic medical center: cost analysis before, during, and after a 7-year program</title><secondary-
title>Infection control and hospital epidemiology</secondary-title></titles><periodical><full-
title>Infection control and hospital epidemiology</full-title></periodical><pages>338-
345</pages><volume>33</volume><number>4</number><dates><year>2012</year></dates><isbn
>0899-823X</isbn><urls></urls></record></Cite></EndNote>}. Similar unsustained effects have

been observed for interventions to improve implementation of sepsis care bundles; with one programme

achieving initial implementation levels of 39% which rapidly reduced to 23% within a year { ADDIN EN.CITE

<EndNote><Cite><Author>Cronshaw</Author><Year>2011</Year><RecNum>148</RecNum><DisplayText>[54, 55]</DisplayText><record><rec-number>148</rec-number><foreign-keys><key app="EN" db-id="pravad92swxz04exa5evrp9pf9fextr9aww5" timestamp="1488198984">148</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Cronshaw, Helen Lindsay</author><author>Daniels, Ron</author><author>Bleetman, Anthony</author><author>Joynes, Emma</author><author>Sheils, Mark</author></authors></contributors><titles><title>Impact of the Surviving Sepsis Campaign on the recognition and management of severe sepsis in the emergency department: are we failing?</title><secondary-title>Emergency Medicine Journal</secondary-title></titles><periodical><full-title>Emergency Medicine Journal</full-title></periodical><pages>670-675</pages><volume>28</volume><number>8</number><dates><year>2011</year></dates><isbn>1472-0213</isbn><urls></urls></record></Cite><Cite><Author>Daniels</Author><Year>2011</Year><RecNum>147</RecNum><record><rec-number>147</rec-number><foreign-keys><key app="EN" db-id="pravad92swxz04exa5evrp9pf9fextr9aww5" timestamp="1488198961">147</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Daniels, Ron</author><author>Nutbeam, Tim</author><author>McNamara, Georgina</author><author>Galvin, Clare</author></authors></contributors><titles><title>The sepsis six and the severe sepsis resuscitation bundle: a prospective observational cohort study</title><secondary-title>Emergency Medicine Journal</secondary-title></titles><periodical><full-title>Emergency Medicine Journal</full-title></periodical><pages>507-512</pages><volume>28</volume><number>6</number><dates><year>2011</year></dates><isbn>1472-0213</isbn><urls></urls></record></Cite></EndNote>}.</p></div>

{ PAGE * MERGEFORMAT }

Investigating implementation and sustainability of interventions in practice is often the focus of process evaluations, which aim to examine ‘how’ and ‘why’ interventions succeed or fail in attaining target outcomes { ADDIN EN.CITE

<EndNote><Cite><Author>Moore</Author><Year>2015</Year><RecNum>65</RecNum><DisplayText>[42]</DisplayText><record><rec-number>65</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508167967">65</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Moore, Graham F</author><author>Audrey, Suzanne</author><author>Barker, Mary</author><author>Bond, Lyndal</author><author>Bonell, Chris</author><author>Hardeman, Wendy</author><author>Moore, Laurence</author><author>O’Cathain, Alicia</author><author>Tinati, Tannaze</author><author>Wight, Daniel</author></authors></contributors><titles><title>Process evaluation of complex interventions: Medical Research Council guidance</title><secondary-title>bmj</secondary-title></titles><periodical><full-title>Bmj</full-

title></periodical><pages>h1258</pages><volume>350</volume><dates><year>2015</year></dates><isbn>1756-1833</isbn><urls></urls></record></Cite></EndNote>}. The benefits of conducting

process evaluations are widely recognised { ADDIN EN.CITE

<EndNote><Cite><Author>Linnan</Author><Year>2002</Year><RecNum>63</RecNum><DisplayText>[51]</DisplayText><record><rec-number>63</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508167860">63</key></foreign-keys><ref-type name="Book">6</ref-type><contributors><authors><author>Linnan, Laura</author><author>Steckler, Allan</author></authors></contributors><titles><title>Process evaluation for public health interventions and research</title></titles><dates><year>2002</year></dates><publisher>Jossey-Bass San Francisco</publisher><isbn>0787959766</isbn><urls></urls></record></Cite></EndNote>}. In

addition to faults in intervention design, interventions may achieve limited effects because the intervention is implemented with inadequate fidelity (i.e., not strictly as intended), with inappropriate ‘dosage’ or intensity, with poor coverage of target participants or services – and so on. Conversely,

interventions may achieve intended outcomes despite inconsistent or poor implementation { ADDIN EN.CITE

<EndNote><Cite><Author>Moore</Author><Year>2015</Year><RecNum>65</RecNum><DisplayText>[42]</DisplayText><record><rec-number>65</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508167967">65</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Moore, Graham F</author><author>Audrey, Suzanne</author><author>Barker, Mary</author><author>Bond, Lyndal</author><author>Bonell, Chris</author><author>Hardeman, Wendy</author><author>Moore, Laurence</author><author>O’Cathain, Alicia</author><author>Tinati, Tannaze</author><author>Wight, Daniel</author></authors></contributors><titles><title>Process evaluation of complex interventions: Medical Research Council guidance</title><secondary-title>bmj</secondary-title></titles><periodical><full-title>Bmj</full-

title></periodical><pages>h1258</pages><volume>350</volume><dates><year>2015</year></dates><isbn>1756-1833</isbn><urls></urls></record></Cite></EndNote>}. Interventions may also have

unintended or unexpected consequences on a service or organisation, which typically extend beyond the initial remit of changing a behaviour or improving a practice { ADDIN EN.CITE

<EndNote><Cite><Author>Toma</Author><Year>2017</Year><RecNum>71</RecNum><DisplayText>[56]</DisplayText><record><rec-number>71</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1518175464">71</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Toma, Madalina</author><author>Davey, Peter G</author><author>Marwick, Charis A</author><author>Guthrie, Bruce</author></authors></contributors><titles><title>A framework for ensuring a balanced accounting of the impact of antimicrobial stewardship interventions</title><secondary-title>Journal of Antimicrobial Chemotherapy</secondary-title></titles><periodical><full-title>Journal of antimicrobial chemotherapy</full-title></periodical><pages>3223-

3231</pages><volume>72</volume><number>12</number><dates><year>2017</year></dates><is

bn>0305-7453</isbn><urls></urls></record></Cite></EndNote>}. Process evaluations can thus assess programme fidelity as well as barriers and facilitators to implementation. Such findings can increase scientific confidence by enabling more accurate interpretation of intervention outcomes.

The UK MRC has recently published updated guidance for designing and conducting process evaluations for complex interventions, which was led by social and behavioural scientists { ADDIN EN.CITE

<EndNote><Cite><Author>Moore</Author><Year>2015</Year><RecNum>65</RecNum><DisplayText>[42]</DisplayText><record><rec-number>65</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508167967">65</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Moore, Graham F</author><author>Audrey, Suzanne</author><author>Barker, Mary</author><author>Bond, Lyndal</author><author>Bonell, Chris</author><author>Hardeman, Wendy</author><author>Moore, Laurence</author><author>O’Cathain, Alicia</author><author>Tinati, Tannaze</author><author>Wight, Daniel</author></authors></contributors><titles><title>Process evaluation of complex interventions: Medical Research Council guidance</title><secondary-title>bmj</secondary-title></titles><periodical><full-title>Bmj</full-

title></periodical><pages>h1258</pages><volume>350</volume><dates><year>2015</year></dates><isbn>1756-1833</isbn><urls></urls></record></Cite></EndNote>}. Process evaluations frequently use behavioural and social science methods, including:ethnography (i.e. in-depth observational study of practices and behaviours in their natural settings) and qualitative and interviews { ADDIN EN.CITE

<EndNote><Cite><Author>Linnan</Author><Year>2002</Year><RecNum>63</RecNum><DisplayText>[51]</DisplayText><record><rec-number>63</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508167860">63</key></foreign-keys><ref-type name="Book">6</ref-type><contributors><authors><author>Linnan, Laura</author><author>Steckler, Allan</author></authors></contributors><titles><title>Process

evaluation for public health interventions and research

research

2002

Jossey-Bass San Francisco

0787959766

For example, an ethnographic process evaluation of *Matching Michigan*, { ADDIN EN.CITE

Bion

2012

59

[57]

59

key app="EN" db-id="255wf9pr9wpd0eeafq5sfx9vetfvw9sfpas" timestamp="1508231494">59

17

Bion, Julian

Richardson, Annette

Hibbert, Peter

Beer, Jeanette

Abrusci, Tracy

McCutcheon, Martin

Cassidy, Jane

Eddleston, Jane

Gunning, Kevin

Bellingan, Geoff

'Matching Michigan': a 2-year stepped interventional programme to minimise central venous catheter-blood stream infections in intensive care units in England

BMJ Qual Saf

BMJ Qual Saf

bmjqs-2012-001325

2012

2044-5415

a UK national programme to reduce central line infections in intensive care units (ICUs) modelled on a successful US programme to change behaviour and culture, reported challenges in replicating the core components of the programme. It also highlighted how the impact of the program was modified by the national and local context. Engagement with the program overall was undermined by a history of national infection control policies coupled with heavy-handed use of performance management-based strategies. Impact of the programme at the level of individual ICUs was influenced by the unit's past experience of quality improvement, local culture, leadership, and the quality of data collection and feedback systems { ADDIN EN.CITE

Dixon-Woods

2013

58

[58]

record><rec-number>58</rec-number><foreign-keys><key app="EN" db-id="255wf9pr9wpd0eeafq5sfx9vetfvw9sfpas" timestamp="1508229688">58</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Dixon-Woods, Mary</author><author>Leslie, Myles</author><author>Tarrant, Carolyn</author><author>Bion, Julian</author></authors></contributors><titles><title>Explaining Matching Michigan: an ethnographic study of a patient safety program</title><secondary-title>Implementation science</secondary-title></titles><periodical><full-title>Implementation Science</full-title></periodical><pages>70</pages><volume>8</volume><number>1</number><dates><year>2013</year></dates><isbn>1748-5908</isbn><urls></urls></record></Cite></EndNote>}.
 An additional example of a process evaluation is a qualitative study of a programme to improve sepsis detection and management through the implementation of the Sepsis Six care bundle, using ethnographic methods { ADDIN EN.CITE

<EndNote><Cite><Author>Tarrant</Author><Year>2016</Year><RecNum>61</RecNum><DisplayText>[59, 60]</DisplayText><record><rec-number>61</rec-number><foreign-keys><key app="EN" db-id="255wf9pr9wpd0eeafq5sfx9vetfvw9sfpas" timestamp="1508232450">61</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Tarrant, Carolyn</author><author>O'Donnell, Barbara</author><author>Martin, Graham</author><author>Bion, Julian</author><author>Hunter, Alison</author><author>Rooney, Kevin D</author></authors></contributors><titles><title>A complex endeavour: an ethnographic study of the implementation of the Sepsis Six clinical care bundle</title><secondary-title>Implementation Science</secondary-title></titles><periodical><full-title>Implementation Science</full-title></periodical><pages>149</pages><volume>11</volume><number>1</number><dates><year>2016</year></dates><isbn>1748-5908</isbn><urls></urls></record></Cite><Cite><Author>Roberts</Author><Year>2017</Year><RecNum>62</RecNum><record><rec-number>62</rec-number><foreign-keys><key app="EN" db-

id="255wf9pr9wpd0eeafq5sfx9vetfvw9sfpas" timestamp="1508232499">62</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Roberts, Neil</author><author>Hooper, Guy</author><author>Lorencatto, Fabiana</author><author>Storr, Wendell</author><author>Spivey, Michael</author></authors></contributors><titles><title>Barriers and facilitators towards implementing the Sepsis Six care bundle (BLISS-1): a mixed methods investigation using the theoretical domains framework</title><secondary-title>Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine</secondary-title></titles><periodical><full-title>Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine</full-title></periodical><pages>96</pages><volume>25</volume><number>1</number><dates><year>2017</year></dates><isbn>1757-7241</isbn><urls></urls></record></Cite></EndNote>}. This study showed that hospitals used effective implementation strategies to change behaviours through engaging, reminding, and educating staff. These strategies targeted staff's motivation, recall and capability to complete the Sepsis Six care bundle within the target timeframe. However, staff also faced additional unanticipated challenges that arose from difficulties in coordinating multiple interdependent tasks, prioritisation, and scheduling. This highlighted the need for additional strategies to increase implementation, such as allocating specific roles and responsibilities for completing the Sepsis Six in ways that reduced the need for coordination and task switching, and the use of process mapping to identify system failures along the trajectory { ADDIN EN.CITE

<EndNote><Cite><Author>Tarrant</Author><Year>2016</Year><RecNum>61</RecNum><DisplayText>[59]</DisplayText><record><rec-number>61</rec-number><foreign-keys><key app="EN" db-id="255wf9pr9wpd0eeafq5sfx9vetfvw9sfpas" timestamp="1508232450">61</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Tarrant, Carolyn</author><author>O'Donnell, Barbara</author><author>Martin, Graham</author><author>Bion, Julian</author><author>Hunter, Alison</author><author>Rooney, Kevin D</author></authors></contributors><titles><title>A complex endeavour: an ethnographic study of the implementation of the Sepsis Six clinical care bundle</title><secondary-title>Implementation Science</secondary-title></titles><periodical><full-title>Implementation

Science

title></periodical><pages>149</pages><volume>11</volume><number>1</number><dates><year>2016</year></dates><isbn>1748-5908</isbn><urls></urls></record></Cite></EndNote>}.</p></div>
<div data-bbox="114 184 886 380" data-label="Text">
<p>Collectively such findings demonstrate barriers to implementation of interventions and the work required to embed an intervention in practice; issues that may be overlooked in developing strategies for widespread and sustained improvements. A key lesson to learn from these examples is that interventions may not be implemented in practice as intended, and improvements may be impeded by unanticipated contextual factors or barriers arising from local systems and cultures. As such assessing implementation using social scientific methods is vital for enabling successful and sustainable implementation of interventions.</p>
</div>
<div data-bbox="144 402 613 419" data-label="Section-Header">
<h4>4. Evidence synthesis and detailed intervention reporting</h4>
</div>
<div data-bbox="114 441 886 909" data-label="Text">
<p>A final area where behavioural and social sciences can contribute to behaviour change in antimicrobial stewardship is through maximising potential learning, by supporting evidence syntheses and improved intervention reporting. A frequent finding from systematic reviews is that the effectiveness of behaviour change interventions is highly variable, with limited clarity as to what makes one intervention more effective than another { ADDIN EN.CITE <EndNote><Cite><Author>Ivers</Author><Year>2012</Year><RecNum>62</RecNum><DisplayText>[48]</DisplayText><record><rec-number>62</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508166044">62</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Ivers, Noah</author><author>Jamtvedt, Gro</author><author>Flottorp, Signe</author><author>Young, Jane M</author><author>Odgaard- Jensen, Jan</author><author>French, Simon D</author><author>O'Brien, Mary Ann</author><author>Johansen, Marit</author><author>Grimshaw, Jeremy</author><author>Oxman, Andrew D</author></authors></contributors><titles><title>Audit and feedback: effects on professional practice and healthcare outcomes</title><secondary-title>The Cochrane Library</secondary-title></titles><periodical><full-title>The Cochrane Library</full-
</p>
</div>
<div data-bbox="651 921 886 939" data-label="Page-Footer">
<p>{ PAGE * MERGEFORMAT }</p>
</div>

title></periodical><dates><year>2012</year></dates><isbn>1465-

1858</isbn><urls></urls></record></Cite></EndNote>}. The application of behavioural and social sciences theories and frameworks in evidence syntheses can help disentangle observed heterogeneity to identify the ‘active ingredients’ of interventions that are associated with increased effect estimates { ADDIN EN.CITE

<EndNote><Cite><Author>Ivers</Author><Year>2014</Year><RecNum>63</RecNum><DisplayText>[61]</DisplayText><record><rec-number>63</rec-number><foreign-keys><key app="EN" db-id="255wf9pr9wpd0eeafq5sfx9vetfvw9sfpas" timestamp="1508235717">63</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Ivers, Noah M</author><author>Sales, Anne</author><author>Colquhoun, Heather</author><author>Michie, Susan</author><author>Foy, Robbie</author><author>Francis, Jill J</author><author>Grimshaw, Jeremy M</author></authors></contributors><titles><title>No more ‘business as usual’ with audit and feedback interventions: towards an agenda for a reinvigorated intervention</title><secondary-title>Implementation Science</secondary-title></titles><periodical><full-title>Implementation Science</full-

title></periodical><pages>14</pages><volume>9</volume><number>1</number><dates><year>2014</year></dates><isbn>1748-5908</isbn><urls></urls></record></Cite></EndNote>}. For example, in the Cochrane review of ASPs the main comparison was between any intervention to improve antibiotic prescribing for hospital versus standard practice (i.e. no intervention) { ADDIN EN.CITE

<EndNote><Cite><Author>Davey</Author><Year>2017</Year><RecNum>45</RecNum><DisplayText>[11]</DisplayText><record><rec-number>45</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508152913">45</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Davey, Peter</author><author>Marwick, Charis A</author><author>Scott, Claire L</author><author>Charani, Esmita</author><author>McNeil, Kirsty</author><author>Brown, Erwin</author><author>Gould, Ian M</author><author>Ramsay, Craig R</author><author>Michie,

Susan

Interventions to improve antibiotic prescribing practices for hospital inpatients

The Cochrane Library

The Cochrane Library

2017

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1858

To explore heterogeneity, the BCW {

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Michie

2011

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app="EN"

db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508161927">59

Michie,

Susan

van Stralen, Maartje M

West,

Robert

The behaviour change wheel: a new method for characterising and designing behaviour change interventions

Implementation science

Implementation Science

42

6

1

20

11

1748-5908

was applied as a coding framework to classify the functions of included interventions, as described in published reports, and the behaviour change technique taxonomy {

ADDIN

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Michie

2013

60

[43]

60

app="EN"

db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508161974">60

Michie,

Susan

Richardson,

Michelle

Johnston,

Marie

Abraham,

Charles

Francis,

Jill

Hardeman, Wendy

Eccles, Martin P

Cane,

James

Wood, Caroline E

The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an

international consensus for the reporting of behavior change interventions

Annals of behavioral medicine

Annals of behavioral medicine

81-95

46

1

2013

0883-6612

} was used to identify and characterise the components of included interventions. Analyses of effect modifiers in 29 randomized controlled trials and 91 interrupted time series studies showed that interventions which included either the BCW function ‘enablement’ or ‘restriction’ were associated with greater improvements in outcomes, and interventions including both functions had cumulative effects. The ability to identify which specific intervention components were associated with increased effectiveness was limited by the fact that few studies included behaviour change techniques, such as goal setting or action planning. However, enabling interventions that also included the behaviour change technique ‘feedback on behaviour’ were shown to be more effective than those that did not include feedback { ADDIN EN.CITE

<EndNote><Cite><Author>Davey</Author><Year>2017</Year><RecNum>45</RecNum><DisplayText>[11]</DisplayText><record><rec-number>45</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508152913">45</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Davey, Peter</author><author>Marwick, Charis A</author><author>Scott, Claire L</author><author>Charani, Esmita</author><author>McNeil, Kirsty</author><author>Brown, Erwin</author><author>Gould, Ian M</author><author>Ramsay, Craig R</author><author>Michie, Susan</author></authors></contributors><titles><title>Interventions to improve antibiotic prescribing practices for hospital inpatients</title><secondary-title>The Cochrane Library</secondary-title></titles><periodical><full-title>The Cochrane Library</full-title></periodical><dates><year>2017</year></dates><isbn>1465-1858</isbn></urls></urls></record></Cite></EndNote>}. Such findings go beyond addressing the issue of whether ASPs are effective, and point to the specific types of interventions and components that contribute to effectiveness. The inclusion of such functions and techniques in the design of future ASPs, or the refinement of existing ASPs, has the potential to maximise likely effectiveness.

What we can learn from syntheses of the published literature is, however, often limited by the systemic issue of sub-optimal, sometimes cursory, reporting of behavioural interventions { ADDIN EN.CITE <EndNote><Cite><Author>Michie</Author><Year>2009</Year><RecNum>8</RecNum><DisplayText>[62]</DisplayText><record><rec-number>8</rec-number><foreign-keys><key app="EN" db-id="255wf9pr9wpd0eeafq5sfx9vetfvw9sfpas" timestamp="1507028932">8</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Michie, Susan</author><author>Fixsen, Dean</author><author>Grimshaw, Jeremy M</author><author>Eccles, Martin P</author></authors></contributors><titles><title>Specifying and reporting complex behaviour change interventions: the need for a scientific method</title><secondary-title>Implementation Science</secondary-title></titles><periodical><full-title>Implementation Science</full-title></periodical><pages>40</pages><volume>4</volume><number>1</number><dates><year>2009</year></dates><isbn>1748-5908</isbn><urls></urls></record></Cite></EndNote>}. Reviews have shown that on average only 50% of the original intervention components are fully described in published reports { ADDIN EN.CITE <EndNote><Cite><Author>Glasziou</Author><Year>2014</Year><RecNum>65</RecNum><DisplayText>[63, 64]</DisplayText><record><rec-number>65</rec-number><foreign-keys><key app="EN" db-id="255wf9pr9wpd0eeafq5sfx9vetfvw9sfpas" timestamp="1508238020">65</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Glasziou, Paul</author><author>Altman, Douglas G</author><author>Bossuyt, Patrick</author><author>Boutron, Isabelle</author><author>Clarke, Mike</author><author>Julious, Steven</author><author>Michie, Susan</author><author>Moher, David</author><author>Wager, Elizabeth</author></authors></contributors><titles><title>Reducing waste from incomplete or unusable reports of biomedical research</title><secondary-title>The Lancet</secondary-title></titles><periodical><full-title>The Lancet</full-title></periodical><pages>267-276</pages><volume>383</volume><number>9913</number><dates><year>2014</year></dates><isbn>0140-

6736</isbn><urls></urls></record></Cite><Cite><Author>Lorencatto</Author><Year>2012</Year>
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 Fabiana</author><author>West, Robert</author><author>Stavri, Zoe</author><author>Michie,
 Susan</author></authors></contributors><titles><title>How well is intervention content described in
 published reports of smoking cessation interventions?</title><secondary-title>nicotine & tobacco
 research</secondary-title></titles><periodical><full-title>nicotine & tobacco research</full-
 title></periodical><pages>1273-
 1282</pages><volume>15</volume><number>7</number><dates><year>2012</year></dates><isb
 n>1469-994X</isbn><urls></urls></record></Cite></EndNote>}. Where detail is provided, this
 typically concerns the delivery parameters of the intervention rather than specifics around the
 intervention content and underlying theory. Furthermore, variable terminology is often used, with
 different labels applied interchangeably to describe the same component techniques in behavioural
 interventions (e.g. ‘daily diaries’ vs ‘self-monitoring’) { ADDIN EN.CITE
 <EndNote><Cite><Author>Michie</Author><Year>2009</Year><RecNum>8</RecNum><Display
 Text>[62]</DisplayText><record><rec-number>8</rec-number><foreign-keys><key app="EN" db-
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 M</author><author>Eccles, Martin P</author></authors></contributors><titles><title>Specifying
 and reporting complex behaviour change interventions: the need for a scientific
 method</title><secondary-title>Implementation Science</secondary-title></titles><periodical><full-
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 title></periodical><pages>40</pages><volume>4</volume><number>1</number><dates><year>20
 09</year></dates><isbn>1748-5908</isbn><urls></urls></record></Cite></EndNote>}. As a result,
 the content of complex behaviour change interventions has been referred to as ‘black boxes’ { ADDIN
 EN.CITE

<EndNote><Cite><Author>Michie</Author><Year>2009</Year><RecNum>8</RecNum><DisplayText>[62]</DisplayText><record><rec-number>8</rec-number><foreign-keys><key app="EN" db-id="255wf9pr9wpd0eeafq5sfx9vetfvw9sfpas" timestamp="1507028932">8</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Michie, Susan</author><author>Fixsen, Dean</author><author>Grimshaw, Jeremy M</author><author>Eccles, Martin P</author></authors></contributors><titles><title>Specifying and reporting complex behaviour change interventions: the need for a scientific method</title><secondary-title>Implementation Science</secondary-title></titles><periodical><full-title>Implementation Science</full-title></periodical><pages>40</pages><volume>4</volume><number>1</number><dates><year>2009</year></dates><isbn>1748-5908</isbn><urls></urls></record></Cite></EndNote>}. This

applies to descriptions of ASPs. The Cochrane review of ASPs reported that the majority of published descriptions lacked critical detail about the design, characteristics and delivery of intervention { ADDIN EN.CITE

<EndNote><Cite><Author>Davey</Author><Year>2015</Year><RecNum>44</RecNum><DisplayText>[5, 12]</DisplayText><record><rec-number>44</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508152886">44</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Davey, Peter</author><author>Peden, Claire</author><author>Charani, Esmita</author><author>Marwick, Charis</author><author>Michie, Susan</author></authors></contributors><titles><title>Time for action—Improving the design and reporting of behaviour change interventions for antimicrobial stewardship in hospitals: Early findings from a systematic review</title><secondary-title>International journal of antimicrobial agents</secondary-title></titles><periodical><full-title>International journal of antimicrobial agents</full-title></periodical><pages>203-212</pages><volume>45</volume><number>3</number><dates><year>2015</year></dates><isbn>0924-8579</isbn><urls></urls></record></Cite>

<Cite><Author>Davey</Author><Year>2013</Year><RecNum>38</RecNum><record><rec-number>38</rec-number><foreign-keys><key app="EN" db-

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Poor or inadequate reporting of behavioural interventions contrasts with descriptions of pharmacological interventions, where the formula, dose, and mechanisms of action are typically reported with precision. There have thus been calls to increase the scientific reporting of behavioural interventions to enable more accurate interpretation and evidence syntheses { ADDIN EN.CITE <EndNote><Cite><Author>Michie</Author><Year>2009</Year><RecNum>8</RecNum><DisplayText>[62]</DisplayText><record><rec-number>8</rec-number><foreign-keys><key app="EN" db-id="255wf9pr9wpd0eeafq5sfx9vetfvw9sfpas" timestamp="1507028932">8</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Michie, Susan</author><author>Fixsen, Dean</author><author>Grimshaw, Jeremy M</author><author>Eccles, Martin P</author></authors></contributors><titles><title>Specifying and reporting complex behaviour change interventions: the need for a scientific method</title><secondary-title>Implementation Science</secondary-title></titles><periodical><full-title>Implementation Science</full-title></periodical><pages>40</pages><volume>4</volume><number>1</number><dates><year>2009</year></dates><isbn>1748-5908</isbn><urls></urls></record></Cite></EndNote>}.

Comprehensive intervention descriptions are also a pre-requisite for replication and implementation of interventions. It is thus important that future studies reporting ASPs fully and transparently report their

interventions, and clearly and consistently label the components. There are a number of tools and frameworks available to facilitate this. Guidelines and reporting checklists have been developed to promote more complete reporting of behavioural interventions { ADDIN EN.CITE { ADDIN EN.CITE.DATA }}

For instance, the TIDieR checklist (i.e. **T**emplate for **I**ntervention **D**escription and **R**eplication) { ADDIN EN.CITE

<EndNote><Cite><Author>Hoffmann</Author><Year>2014</Year><RecNum>66</RecNum><DisplayText>[67]</DisplayText><record><rec-number>66</rec-number><foreign-keys><key app="EN" db-id="255wf9pr9wpd0eeafq5sfx9vetfvw9sfpas" timestamp="1508238026">66</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Hoffmann, Tammy C</author><author>Glasziou, Paul P</author><author>Boutron, Isabelle</author><author>Milne, Ruairidh</author><author>Perera, Rafael</author><author>Moher, David</author><author>Altman, Douglas G</author><author>Barbour, Virginia</author><author>Macdonald, Helen</author><author>Johnston, Marie</author></authors></contributors><titles><title>Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide</title><secondary-title>Bmj</secondary-title></titles><periodical><full-title>bmj</full-title></periodical><pages>g1687</pages><volume>348</volume><dates><year>2014</year></dates><isbn>1756-1833</isbn><urls></urls></record></Cite></EndNote>} recommends including descriptions of: ‘why’ (i.e. intervention rationale, theory, aims), ‘what’ (i.e. materials, procedures, content), ‘who’ (i.e. provider), ‘how,’ ‘where,’ ‘when and how much,’ ‘tailoring,’ ‘modifications,’ and ‘how well’ (i.e. extent of implementation as intended) (see Supplementary File 1 for full checklist). Specifying the ‘what’ (i.e. content of interventions) can be facilitated by using the behaviour change technique taxonomy to describe the techniques constituting the intervention package { ADDIN EN.CITE

<EndNote><Cite><Author>Michie</Author><Year>2013</Year><RecNum>60</RecNum><DisplayText>[43]</DisplayText><record><rec-number>60</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508161974">60</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Michie,

layText>[2]</DisplayText><record><rec-number>14</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">14</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Hulscher, Marlies E.J.L.</author><author>Grol, Richard PTM</author><author>van der Meer, Jos WM</author></authors></contributors><titles><title>Antibiotic prescribing in hospitals: a social and behavioural scientific approach</title><secondary-title>The Lancet infectious diseases</secondary-title></titles><pages>167-

175</pages><volume>10</volume><number>3</number><dates><year>2010</year></dates><isbn>1473-3099</isbn><urls></urls></record></Cite></EndNote>}. Yet the majority of current quality

improvement research and practice in antimicrobial stewardship has not drawn adequately upon the behavioural and social sciences to help address this challenge { ADDIN EN.CITE

<EndNote><Cite><Author>Charani</Author><Year>2011</Year><RecNum>35</RecNum><DisplayText>[14]</DisplayText><record><rec-number>35</rec-number><foreign-keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">35</key></foreign-keys><ref-type

name="Journal Article">17</ref-type><contributors><authors><author>Charani, Esmita</author><author>Edwards, Rachel</author><author>Sevdalis, Nick</author><author>Alexandrou, Banos</author><author>Sibley, Eleanor</author><author>Mullett, David</author><author>Franklin, Bryony Dean</author><author>Holmes, Alison</author></authors></contributors><titles><title>Behavior

change strategies to influence antimicrobial prescribing in acute care: a systematic review</title><secondary-title>Clinical Infectious Diseases</secondary-title></titles><pages>651-662</pages><volume>53</volume><number>7</number><dates><year>2011</year></dates><isbn>1058-4838</isbn><urls></urls></record></Cite></EndNote>}. In order to make best use of what are

often limited quality improvement and research resources, it is necessary to consider how to maximise the potential impact of ASPs. In this paper, we discussed four potential areas where the behavioural and social sciences can help drive sustained behaviour change in antibiotic prescribing. The aim is not to provide ‘magic bullets’ to solving the problem of antimicrobial use in secondary care. It is important to recognise that these disciplines cannot offer a ‘one size fits all’ recommendation for improving

change strategies to influence antimicrobial prescribing in acute care: a systematic review</title><secondary-title>Clinical Infectious Diseases</secondary-title></titles><pages>651-662</pages><volume>53</volume><number>7</number><dates><year>2011</year></dates><isbn>1058-4838</isbn><urls></urls></record></Cite></EndNote>}. In order to make best use of what are

often limited quality improvement and research resources, it is necessary to consider how to maximise the potential impact of ASPs. In this paper, we discussed four potential areas where the behavioural and social sciences can help drive sustained behaviour change in antibiotic prescribing. The aim is not to provide ‘magic bullets’ to solving the problem of antimicrobial use in secondary care. It is important to recognise that these disciplines cannot offer a ‘one size fits all’ recommendation for improving

change strategies to influence antimicrobial prescribing in acute care: a systematic review</title><secondary-title>Clinical Infectious Diseases</secondary-title></titles><pages>651-662</pages><volume>53</volume><number>7</number><dates><year>2011</year></dates><isbn>1058-4838</isbn><urls></urls></record></Cite></EndNote>}. In order to make best use of what are

often limited quality improvement and research resources, it is necessary to consider how to maximise the potential impact of ASPs. In this paper, we discussed four potential areas where the behavioural and social sciences can help drive sustained behaviour change in antibiotic prescribing. The aim is not to provide ‘magic bullets’ to solving the problem of antimicrobial use in secondary care. It is important to recognise that these disciplines cannot offer a ‘one size fits all’ recommendation for improving

change strategies to influence antimicrobial prescribing in acute care: a systematic review</title><secondary-title>Clinical Infectious Diseases</secondary-title></titles><pages>651-662</pages><volume>53</volume><number>7</number><dates><year>2011</year></dates><isbn>1058-4838</isbn><urls></urls></record></Cite></EndNote>}. In order to make best use of what are

stewardship behaviours, nor would they wish to do so. The overarching principle and recommendation is that any strategy to change behaviour should be targeted and context specific, and informed by a thorough understanding of the factors influencing the behaviour of interest.

Nonetheless, regardless of context, healthcare quality improvement almost always requires change, typically behaviour change. The behavioural and social sciences offer general recommendations as to how to approach behaviour change in a structured, theory- and evidence-informed way that is more likely to be effective. These include:

- **Do not ‘rush’ to intervention.** Often those working in quality improvement skip straight to ‘doing’ or ‘trying something’ (i.e. intervening) without first considering their rationale for their choice of specific intervention strategy or planning for its implementation and evaluation. Instead, the behavioural and social sciences recommend intervention designers:
- **Be specific about what you wish to change:** Start by defining your ‘problem’ of interest in behavioural terms, as precisely as possible { ADDIN EN.CITE <EndNote><Cite><Author>Michie</Author><Year>2014</Year><RecNum>15</RecNum><DisplayText>[22]</DisplayText><record><rec-number>15</rec-number><foreign-keys><key app="EN" db-id="fp2srrssqa52zvesf07p9zetsxa9a90w9wsw" timestamp="1525863931">15</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Michie, Susan</author><author>Atkins, Lou</author><author>West, Robert</author></authors></contributors><titles><title>The behaviour change wheel: a guide to designing interventions</title><secondary-title>Needed: physician leaders</secondary-title></titles><volume>26</volume><dates><year>2014</year></dates><urls></urls></record></Cite></EndNote>}. Map out the ‘system’ of different behaviours that might be contributing to your problem (e.g. prescribing, reviewing, initiating or stopping antibiotics). Importantly, consider whose behaviour needs to change? To what extent? Where, when and for whom (e.g. which patient groups)? The ‘who’ is of particular importance in healthcare quality improvement as often more than one healthcare professional group needs to change their

behaviour (e.g. pharmacists, nurses, doctors) { ADDIN EN.CITE

<EndNote><Cite><Author>Francis</Author><Year>2016</Year><RecNum>39</RecNum>

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: A FRAMEWORK FOR SPECIFYING BEHAVIOUR AND ITS COMPLEXITY IN

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JOURNAL OF BEHAVIORAL MEDICINE</secondary-title></titles><pages>S77-

S77</pages><volume>23</volume><dates><year>2016</year></dates><publisher>SPRIN

GER 233 SPRING ST, NEW YORK, NY 10013 USA</publisher><isbn>1070-

5503</isbn><urls></urls></record></Cite></EndNote>}. Select a specific behaviour to target

based on likely feasibility, generalisability, safety, acceptability and impact { ADDIN EN.CITE

<EndNote><Cite><Author>Michie</Author><Year>2014</Year><RecNum>15</RecNum>

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Susan</author><author>Atkins,

Lou</author><author>West,

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- Conduct a ‘behavioural diagnosis,’ considering the broader social and environmental context:** Ask yourself: *What is current behaviour? Why is it the way it is? What factors are facilitating or hindering the target behaviour? What would need to change in order for the target behaviour to occur?* Look beyond lack knowledge and resource deficits, as these are rarely the only barriers. Indeed, the evidence summarised in this review highlights that there are numerous wide-ranging, interrelated factors influencing antimicrobial stewardship, particularly social and cultural influences { ADDIN EN.CITE <EndNote><Cite><Author>Charani</Author><Year>2017</Year><RecNum>21</RecNum ><DisplayText>[37, 38]</DisplayText><record><rec-number>21</rec-number><foreign-keys><key app="EN" db-id="fp2srrssqa52zvesf07p9zetsxa9a90w9wsw" timestamp="1525863931">21</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Charani,
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keys><key app="EN" db-id="r9reteza6epetsef9t35ppw72fxfawpt2d9r" timestamp="0">18</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Charani, Esmita</author><author>Castro-Sanchez, E</author><author>Sevdalis, N</author><author>Kyratsis, Y</author><author>Drumright, L</author><author>Shah, N</author><author>Holmes, A</author></authors></contributors><titles><title>Understanding the determinants of antimicrobial prescribing within hospitals: the role of “prescribing etiquette”</title><secondary-title>Clinical Infectious Diseases</secondary-title></titles><pages>188-196</pages><volume>57</volume><number>2</number><dates><year>2013</year></dates><isbn>1058-4838</isbn><urls></urls></record></Cite></EndNote>}. The behavioural and social sciences offer a number of theories and models that outline potential factors to consider (e.g. COM-B, Theoretical Domains Framework{ ADDIN EN.CITE { ADDIN EN.CITE.DATA }}, and methods of scientific enquiry through which to investigate these (e.g. qualitative interviews, ethnography).

- **Consider full range of intervention strategies and techniques. Match the selection of intervention to your behavioural diagnosis:** Interventions to change behaviour are more likely to be effective if they are designed to target the key factors influencing the behaviour of interest { ADDIN EN.CITE <EndNote><Cite><Author>Michie</Author><Year>2008</Year><RecNum>61</RecNum><DisplayText>[40]</DisplayText><record><rec-number>61</rec-number><foreign-keys><key app="EN" db-id="fee52sff3vvv50eepwy5p5pav2pssveprwfa" timestamp="1508162635">61</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Michie, Susan</author><author>Johnston, Marie</author><author>Francis, Jill</author><author>Hardeman, Wendy</author><author>Eccles, Martin</author></authors></contributors><titles><title>From theory to intervention: mapping theoretically derived behavioural determinants to behaviour change

techniques</title><secondary-title>Applied psychology</secondary-title></titles><periodical><full-title>Applied psychology</full-title></periodical><pages>660-680</pages><volume>57</volume><number>4</number><dates><year>2008</year></dates><isbn>1464-0597</isbn><urls></urls></record></Cite></EndNote>}. If education is rarely the only barrier, then education alone is unlikely to be the solution. Therefore, rather than base the choice of intervention strategy on the basis of (potentially inaccurate) intuitive assumptions or guesses as to what needs to change, design the intervention on the basis of a contextual 'behavioural diagnosis.' Consider the full range of potential intervention strategies and techniques and select those that are most congruent with the barriers/enablers to the behaviour you are trying to change { ADDIN EN.CITE <EndNote><Cite><Author>Michie</Author><Year>2014</Year><RecNum>15</RecNum><DisplayText>[22, 30]</DisplayText><record><rec-number>15</rec-number><foreign-keys><key app="EN" db-id="fp2srrssqa52zvesf07p9zetsxa9a90w9ws" timestamp="1525863931">15</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Michie, Susan</author><author>Atkins, Lou</author><author>West, Robert</author></authors></contributors><titles><title>The behaviour change wheel: a guide to designing interventions</title><secondary-title>Needed: physician leaders</secondary-title></titles><volume>26</volume><dates><year>2014</year></dates><urls></urls></record></Cite><Cite><Author>Michie</Author><Year>2011</Year><RecNum>25</RecNum><record><rec-number>25</rec-number><foreign-keys><key app="EN" db-id="fp2srrssqa52zvesf07p9zetsxa9a90w9ws" timestamp="1525863931">25</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Michie, Susan</author><author>van Stralen, Maartje M</author><author>West, Robert</author></authors></contributors><titles><title>The behaviour change wheel: a new method for characterising and designing behaviour change interventions</title><secondary-

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>2011</year></dates><isbn>1748-5908</isbn><urls></urls></record></Cite></EndNote>}.
Behavioural science offers numerous inter-linked frameworks to guide decision-making and
facilitate this process in a structured and transparent manner, of which the Behaviour Change
Wheel is just one { ADDIN EN.CITE { ADDIN EN.CITE.DATA }}. It is possible to adopt this
approach when designing ‘new’ interventions, but also to identify opportunities to optimise
and/or refine existing interventions that have already been implemented in practice { ADDIN
EN.CITE
<EndNote><Cite><Author>Steinmo</Author><Year>2016</Year><RecNum>9</RecNum>
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year>2016</year></dates><isbn>1748-
5908</isbn><urls></urls></record></Cite></EndNote>}.

- **Look at the evidence in the broader behaviour change literature:** Many intervention strategies that are frequently used in ASPs, such as audit and feedback { ADDIN EN.CITE
<EndNote><Cite><Author>Ivers</Author><Year>2012</Year><RecNum>27</RecNum><

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M.</author><author>Odgaard-Jensen, J.</author><author>French, S.
D.</author><author>O'Brien, M. A.</author><author>Johansen,
M.</author><author>Grimshaw, J.</author><author>Oxman, A.
D.</author></authors></contributors><auth-address>Department of Family Medicine,
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systematic reviews</alt-
title></titles><pages>Cd000259</pages><number>6</number><edition>2012/06/15</editio
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num>10.1002/14651858.CD000259.pub3</electronic-resource-num><remote-database-
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provider><language>Eng</language></record></Cite></EndNote>}, have also been widely used to try and improve the quality of care for other clinical areas and behaviours. There are also an increasing number of systematic reviews applying behavioural science frameworks to their analysis in order to go beyond meta-analyses comparing interventions against standard practice, to disentangling heterogeneity and pinpointing the precise ‘active ingredients’ (i.e. behaviour change techniques) associated with improved effects { ADDIN EN.CITE <EndNote><Cite><Author>Davey</Author><Year>2017</Year><RecNum>8</RecNum><DisplayText>[11]</DisplayText><record><rec-number>8</rec-number><foreign-keys><key app="EN" db-id="fp2srrssqa52zvesf07p9zetsxa9a90w9wsw" timestamp="1525863931">8</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Davey, Peter</author><author>Marwick, Charis A</author><author>Scott, Claire L</author><author>Charani, Esmita</author><author>McNeil, Kirsty</author><author>Brown, Erwin</author><author>Gould, Ian M</author><author>Ramsay, Craig R</author><author>Michie, Susan</author></authors></contributors><titles><title>Interventions to improve antibiotic prescribing practices for hospital inpatients</title><secondary-title>The Cochrane Library</secondary-title></titles><dates><year>2017</year></dates><isbn>1465-1858</isbn><urls></urls></record></Cite></EndNote>}. Therefore, the design and implementation of ASPs may benefit from looking outside of the antimicrobial stewardship context to draw on the evidence, recommendations and lessons learnt from the broader behaviour change literature.

- **Do not assume your intervention will be implemented as intended, nor sustained longer term.** Complex interventions, such as ASPs, may not work as expected when implemented in practice. Furthermore, interventions that have been shown to be initially promising may not sustain their effects longer term, or when implemented on a larger scale or in new settings. Effect estimates alone do not provide policy makers and healthcare systems with the necessary knowledge around factors ‘what works better, for whom, and why,’ needed to inform the

implementation of interventions in new contexts. Therefore, it is vital to also **investigate ‘how’ and ‘why’ interventions are implemented, not just whether or not they are effective.** This can help generalise learning from implementation ‘successes’ as well as ‘failures.’

- **Describe and report your intervention as comprehensively as possible.** What can be learnt from the existing evidence base and quality improvement practice is hampered by poor intervention reporting. There is thus an accompanying need to adopt a more systematic approach to comprehensively describe and document the rationale and content of ASPs, using available reporting guidelines and taxonomies to structure intervention descriptions{ ADDIN EN.CITE

<EndNote><Cite><Author>Hoffmann</Author><Year>2014</Year><RecNum>46</RecNum><DisplayText>[43, 67]</DisplayText><record><rec-number>46</rec-number><foreign-keys><key app="EN" db-id="fp2srrssqa52zvesf07p9zetsxa9a90w9wsw" timestamp="1525863931">46</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Hoffmann, Tammy C</author><author>Glasziou, Paul P</author><author>Boutron, Isabelle</author><author>Milne, Ruairidh</author><author>Perera, Rafael</author><author>Moher, David</author><author>Altman, Douglas G</author><author>Barbour, Virginia</author><author>Macdonald, Helen</author><author>Johnston, Marie</author></authors></contributors><titles><title>Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide</title><secondary-title>Bmj</secondary-title></titles><pages>g1687</pages><volume>348</volume><dates><year>2014</year></dates><isbn>1756-

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E</author></authors></contributors><titles><title>The behavior change technique taxonomy
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95</pages><volume>46</volume><number>1</number><dates><year>2013</year></dates
><isbn>0883-6612</isbn><urls></urls></record></Cite></EndNote>}. This is vital to enable
more accurate intervention of intervention effects and facilitate replication and scalability of
interventions in new settings.

Behavioural and social sciences offer a number of theories, frameworks, methods, and evidence-based principles that can facilitate progress in each of these areas.. However, the potential for behavioural and social sciences to contribute to antimicrobial stewardship is contingent on the urgent need to work collaboratively across disciplines. Although a multidisciplinary approach may require additional time and resource, it is critical to moving the field forward and addressing many of the limitations in intervention design, evaluation and reporting that are currently faced by antimicrobial stewardship research and practice. More importantly, such an approach will help realize the potential to minimise the various health and socio-economic consequences associated with inappropriate antimicrobial prescribing and to combat the threat of antimicrobial resistance.

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Figure 1. The COM-B model of behaviour change

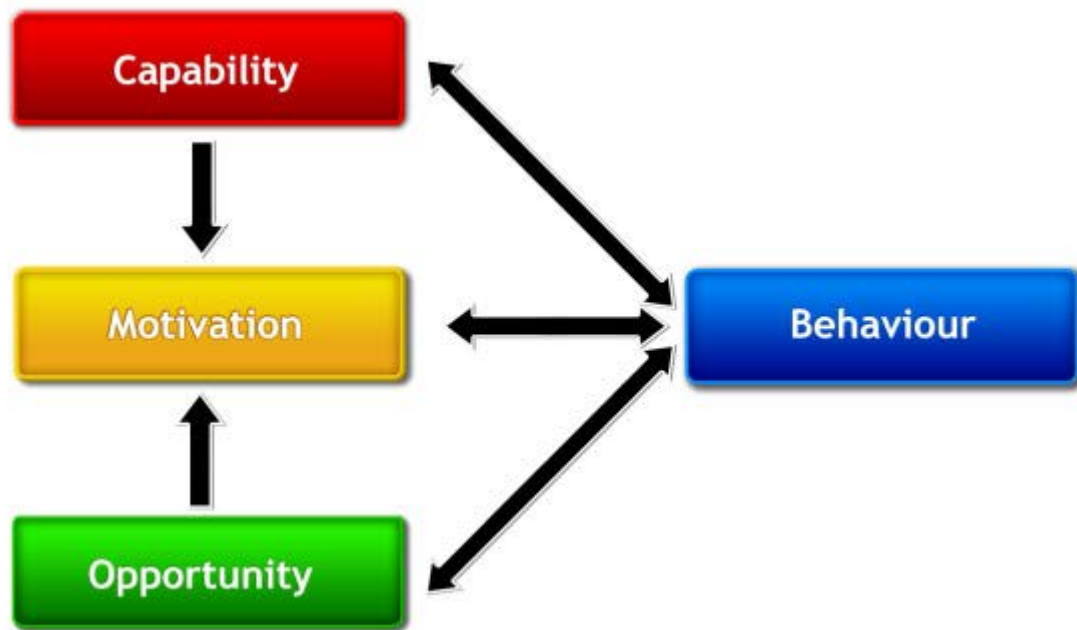


Figure 2. The Behaviour Change Wheel framework [30] and its linkage to the COM-B model and Theoretical Domains Framework

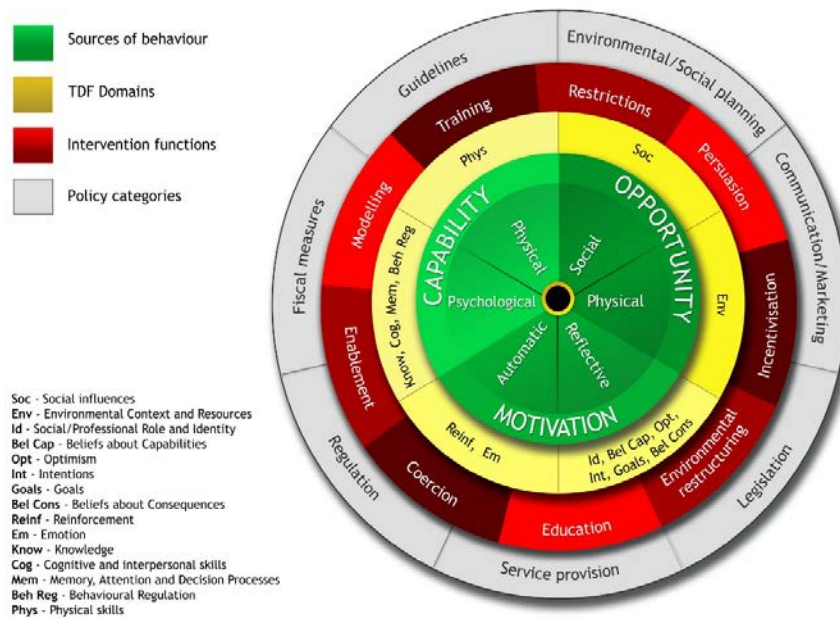
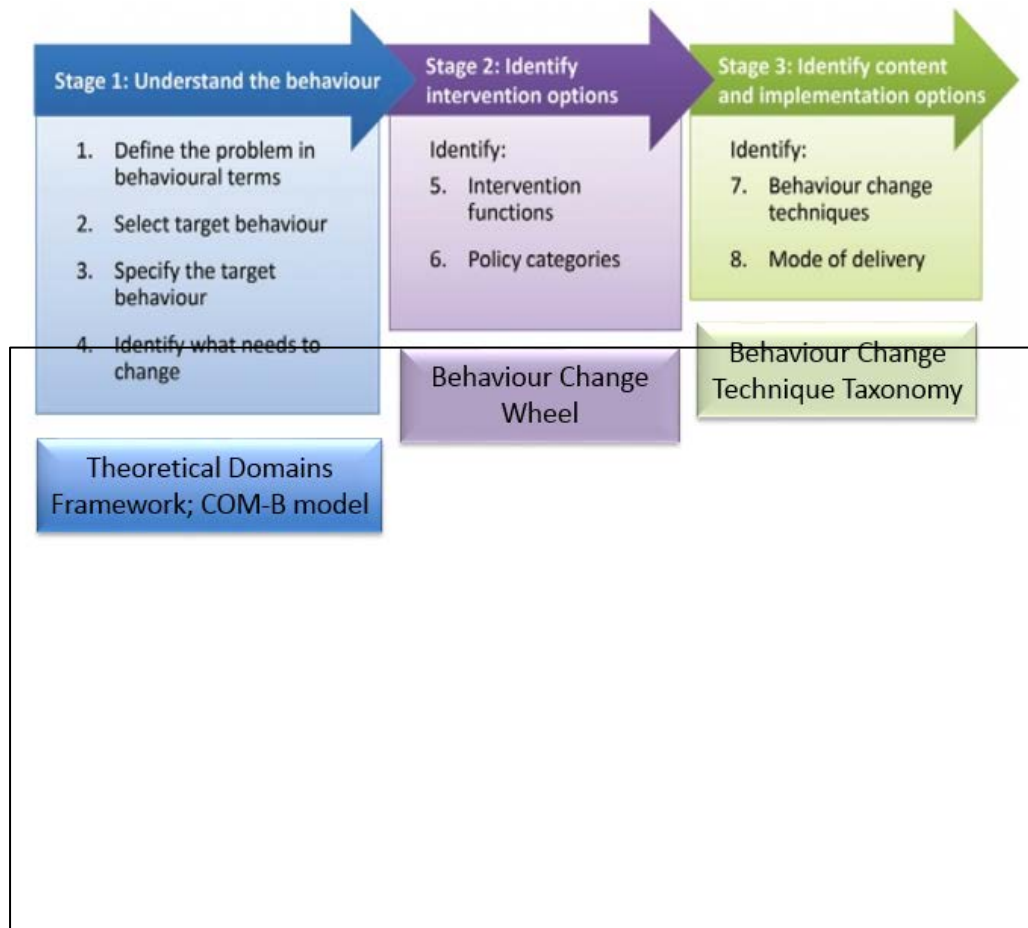


Figure 3. Steps in the Behaviour Change Wheel approach to intervention design



¹ Permission to reproduce Figures 1 and 2 has been obtained from the authors of Michie S, Atkins L, West R. The behaviour change wheel: a guide to designing interventions. 2014;26:146.

Table 1. Domains from the Theoretical Domains Framework and example themes within each domain representing barriers/enablers to antimicrobial prescribing across different clinical contexts

TDF Domain	Definition	Emerging Barrier/Enabler Theme	Study, Setting
Knowledge	An awareness of the existence of something, for example, procedural knowledge	‘Poor clinical microbiology knowledge’	Chaves et al. 2014, Tertiary hospitals
		‘Lack of awareness of clinical guidelines around appropriate antimicrobial prescribing practices’	Fleming et al. 2014, Long-term care facilities
Skills	An ability or proficiency acquired through practice, for example, competence	‘Vacomycin doses are incorrectly adjusted by doctors’	Chaves et al. 2014, Tertiary hospitals
		‘Lack of training specific to geriatric pharmacotherapy and lack of communication of clinically relevant information on drugs to avoid for older patients’	Cullinan et al. 2014, older hospitalised patients
Social Professional Role/ Identity	A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting, for example, professional confidence	‘The role of the pharmacist is primarily to screen for drug interactions and provide medicines information rather than influencing the antibiotic prescribing process’	Fleming et al. 2014, Long-term care facilities
Beliefs about Capabilities	Acceptance of the truth, reality or validity about an ability, talent or facility that a person can put to constructive use, for example, self-confidence	‘Doctors need assistance choosing antimicrobials’	Chaves et al. 2014, Tertiary hospitals
		‘Doctors are confident in deviating from clinical guidelines based on clinical expertise and judgment’	Fleming et al. 2014, Long-term care facilities
Beliefs about consequences	Acceptance of the truth, reality or validity about outcomes of a behaviour in a given situation, for example, outcome expectancies	‘Alternative treatments to remove source of infection (i.e. local measures) sometimes make things worse’	Newlands et al. 2016, General dental practice.
		‘Beliefs that prudent use of antimicrobials will reduce resistance’	Chaves et al. 2014, Tertiary hospitals
Reinforcement	Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus, for example, rewards	‘There are no incentives to conducting local measures to remove the source of infection as an alternative to prescribing antibiotics’	Newlands et al. 2016, General dental practice.
Intention	A conscious decision to perform a behaviour or resolve to act in a certain way, for example, stability of intentions	‘Difficult to know which antibiotics are restricted so I just wait for a pharmacist to tell me’	Chaves et al. 2014, Tertiary hospitals
Goals	Mental representations of outcomes or end states that an individual wants to achieve, for example, goal/target setting	‘Lack of clear targets for antibiotic usage and use of antibiotic care bundles’	Fleming et al. 2014, Long-term care facilities

Optimism	The confidence that things will happen for the best or that desired goals will be attained, for example, optimism, pessimism	'Lack of confidence that local measures as an alternative to prescribing will solve issues successfully on their own'	Newlands et al. 2016, General dental practice.
Memory, Attention, Decision Making	The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives, for example, decision-making	'Antimicrobial prescribing decisions are contingent on the type of patient' 'Highly pressured prescribing environment limits attention doctors can give each patient and their medicines'	Newlands et al. 2016, General dental practice. Cullinan et al. 2014, older hospitalised patients
Environmental context and resources	Any circumstances of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence and adaptive behaviour, for example, resources	'Lack of diagnostic equipment and interpretation of microbiology results is a significant challenge for doctors and nurses' 'Lack of time plays a big part in managing bacterial infections' 'Lack of IT infrastructure'	Fleming et al. 2014, Long-term care facilities Newlands et al. 2016, General dental practice. Cullinan et al. 2014, older hospitalised patients
Social influences	Those interpersonal processes that can cause individuals to change their thoughts, feelings or behaviours, for example, social pressure	'Patient behaviour or demands influence prescribing decisions' 'Nurses acting as a 'gate keeper' role, doctors depend on nurses to detect patients' signs of infection' 'Patients and /or patients' families can influence prescribing, with pressure from patients/families leading doctors to prescribe medications they are not completely happy with'	Newlands et al. 2016, General dental practice. Fleming et al. 2014, Long-term care facilities Cullinan et al. 2014, older hospitalised patients
Emotion	A complex reaction pattern, involving experiential, behavioural and physiological elements, by which the individual attempts to deal with a personally significant matter or event, for example, anxiety	'Anxiety about letting somebody go without antibiotics' 'Antimicrobials are often continued because doctors are worried about missing something'	Newlands et al. 2016, General dental practice. Chaves et al. 2014, Tertiary hospitals
Behavioural regulation	Anything aimed at managing or changing objectively observed or measured actions, for example, self-monitoring	'Desire for audit and feedback on antibiotic prescribing practice'	Newlands et al. 2016, General dental practice.

Table 1. Domains from the COM-B model and Theoretical Domains Framework, with example themes within each domain representing barriers/enablers to antimicrobial prescribing across different clinical contexts

COM-B Component	TDF Domain	Definition	Reported Barrier/Enabler Theme	Study, Setting
CAPABILITY (psychological and physical)	Knowledge	An awareness of the existence of something, for example, procedural knowledge	‘Poor clinical microbiology knowledge’ ‘Lack of awareness of clinical guidelines around appropriate antimicrobial prescribing practices’	Chaves et al. 2014, Tertiary hospitals Fleming et al. 2014, Long-term care facilities
	Skills	An ability or proficiency acquired through practice, for example, competence	‘Vacomycin doses are incorrectly adjusted by doctors’ ‘Lack of training specific to geriatric pharmacotherapy and lack of communication of clinically relevant information on drugs to avoid for older patients’	Chaves et al. 2014, Tertiary hospitals Cullinan et al. 2014, older hospitalised patients
	Memory, Attention, Decision Making	The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives, for example, decision-making	‘Antimicrobial prescribing decisions are contingent on the type of patient’ ‘Highly pressured prescribing environment limits attention doctors can give each patient and their medicines’	Newlands et al. 2016, General dental practice. Cullinan et al. 2014, older hospitalised patients
	Behavioural regulation	Anything aimed at managing or changing objectively observed or measured actions, for example, self-monitoring	‘Desire for audit and feedback on antibiotic prescribing practice’	Newlands et al. 2016, General dental practice.
OPPORTUNITY (Social and physical)	Environmental context and resources	Any circumstances of a person’s situation or environment that discourages or encourages the development of skills and abilities, independence, social competence and	‘Lack of diagnostic equipment and interpretation of microbiology results is a significant challenge for doctors and nurses’ ‘Lack of time plays a big part in managing bacterial infections’	Fleming et al. 2014, Long-term care facilities

COM-B Component	TDF Domain	Definition	Reported Barrier/Enabler Theme	Study, Setting
		adaptive behaviour, for example, resources	'Lack of IT infrastructure'	Newlands et al. 2016, General dental practice. Cullinan et al. 2014, older hospitalised patients
	Social influences	Those interpersonal processes that can cause individuals to change their thoughts, feelings or behaviours, for example, social pressure	'Patient behaviour or demands influence prescribing decisions' 'Nurses acting as a 'gate keeper' role, doctors depend on nurses to detect patients' signs of infection' 'Patients and /or patients' families can influence prescribing, with pressure from patients/families leading doctors to prescribe medications they are not completely happy with'	Newlands et al. 2016, General dental practice. Fleming et al. 2014, Long-term care facilities Cullinan et al. 2014, older hospitalised patients
MOTIVATION (reflective and automatic)	Social Professional Role/ Identity	A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting, for example, professional confidence	'The role of the pharmacist is primarily to screen for drug interactions and provide medicines information rather than influencing the antibiotic prescribing process'	Fleming et al. 2014, Long-term care facilities
	Beliefs about Capabilities	Acceptance of the truth, reality or validity about an ability, talent or facility that a person can put to constructive use, for example, self-confidence	'Doctors need assistance choosing antimicrobials' 'Doctors are confident in deviating from clinical guidelines based on clinical expertise and judgment'	Chaves et al. 2014, Tertiary hospitals Fleming et al. 2014, Long-term care facilities
	Beliefs about consequences	Acceptance of the truth, reality or validity about outcomes of a behaviour in a given situation, for example, outcome expectancies	'Alternative treatments to remove source of infection (i.e. local measures) sometimes make things worse'	Newlands et al. 2016, General dental practice.

COM-B Component	TDF Domain	Definition	Reported Barrier/Enabler Theme	Study, Setting
			'Beliefs that prudent use of antimicrobials will reduce resistance'	Chaves et al. 2014, Tertiary hospitals
	Reinforcement	Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus, for example, rewards	'There are no incentives to conducting local measures to remove the source of infection as an alternative to prescribing antibiotics'	Newlands et al. 2016, General dental practice.
	Intention	A conscious decision to perform a behaviour or resolve to act in a certain way, for example, stability of intentions	'Difficult to know which antibiotics are restricted so I just wait for a pharmacist to tell me'	Chaves et al. 2014, Tertiary hospitals
	Goals	Mental representations of outcomes or end states that an individual wants to achieve, for example, goal/target setting	'Lack of clear targets for antibiotic usage and use of antibiotic care bundles'	Fleming et al. 2014, Long-term care facilities
	Optimism	The confidence that things will happen for the best or that desired goals will be attained, for example, optimism, pessimism	'Lack of confidence that local measures as an alternative to prescribing will solve issues successfully on their own'	Newlands et al. 2016, General dental practice.
	Emotion	A complex reaction pattern, involving experiential, behavioural and physiological elements, by which the individual attempts to deal with a personally significant matter or event, for example, anxiety	'Anxiety about letting somebody go without antibiotics' 'Antimicrobials are often continued because doctors are worried about missing something'	Newlands et al. 2016, General dental practice. Chaves et al. 2014, Tertiary hospitals